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"The Bureau du Roi"—masterpiece of all time in furniture craftsmanship—veneer and plywood construction throughout.

Now in the Louvre, Paris. See pages 50 and 51.

# VENEERS AND PLYWOOD

## Their Craftsmanship and Artistry, Modern Production Methods and Present-Day Utility

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and
MEINRAD WULPI
EDITORS

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# PREFACE

The aim of this book is to set forth the facts, both historical and technical, relating to the origin and present-day production of Veneers and of Plywood. It is designed for the student and teacher in the industrial arts, the prospective purchaser of furniture, the salesman who wishes to be thoroughly well-informed on his merchandise, as well as for the economist and the purposeful reader in general.

In this important field of industry, which is today making a genuine contribution to the service of mankind by its conservation of the diminishing supply of forest products, authentic information has been heretofore scattered and fragmentary. There have been Government bulletins, occasional chapters in natural histories or studies of forest products, paragraphs in furniture books, exhaustive discussions on some particular phase of manufacture, and specific comment in various other authorities. However, a complete compilation of all available information has been lacking. It was to supply this lack of a proper record and adequate presentation of the facts relating to the industry that the preparation of this book was undertaken by a small group of interested persons.

A glance through the table of contents will indicate the broad treatment of the subject—practical helps offered to craftsmen in wood work and cabinetry, as well as extensive and correct information of an educational nature. The various topics and the considerations arising therefrom are treated in as compact a form as the editors have found consistent with the essential facts presented. The historical and commercial developments of Veneer and of Plywood are set forth in natural sequence, from the forest to the Veneer mill, where the wood progresses through various stages of manufacture until, as

single-ply veneer, it is ready for the Plywood manufacturer, who remanufactures and converts it into the finished product known as Plywood.

In the production of good furniture, rare cabinets, beautiful pianos and other musical instruments, panels for doors, interior finish and for aeroplanes; of laminated automobile wheels, veneer packages, box shooks, containers, refrigerators, etc.; in fact, for every purpose where the combination of beauty, reliability, durability and strength, with economy of wood construction, is required, no material has wider or more important uses than the built-up, ply upon ply, layer-construction of "wood-on-wood," called Plywood.

The editors trust that this record of Veneers and of Plywood will serve as a reference book which shall satisfy at once the interest of the student as well as the practical demands of the public for workable facts and figures, together with the "reasons why" of these important industries.

They also desire to make it clear that in compiling so much original and detailed information on the history and practices of the industry, they have drawn extensively on the resources of the manufacturers of Veneer and of Plywood and on the goodwill of makers of machinery and equipment.

The leading manufacturers of Veneer and of Plywood have shown deep interest in the preparation of this volume and have lent every aid within their power. Especial credit is due to the following:

Genevieve M. Edmonds, Wausau, Wis.
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Wherever possible, credit has been given to those who have supplied photographs, drawings, charts and tabulations, and any omission of proper credit is due to no other cause but inadvertence.

Many authors and publishers of books and other treatises, have been helpful in allowing liberal extracts, for which credit has been extended in footnotes.

The co-operation so courteously extended by various libraries and museums is appreciated, and in addition, thanks are extended to many others whose aid and assistance have helped in the task of telling the story of Veneers and of Plywood.

THE EDITORS.

January 16, 1927.

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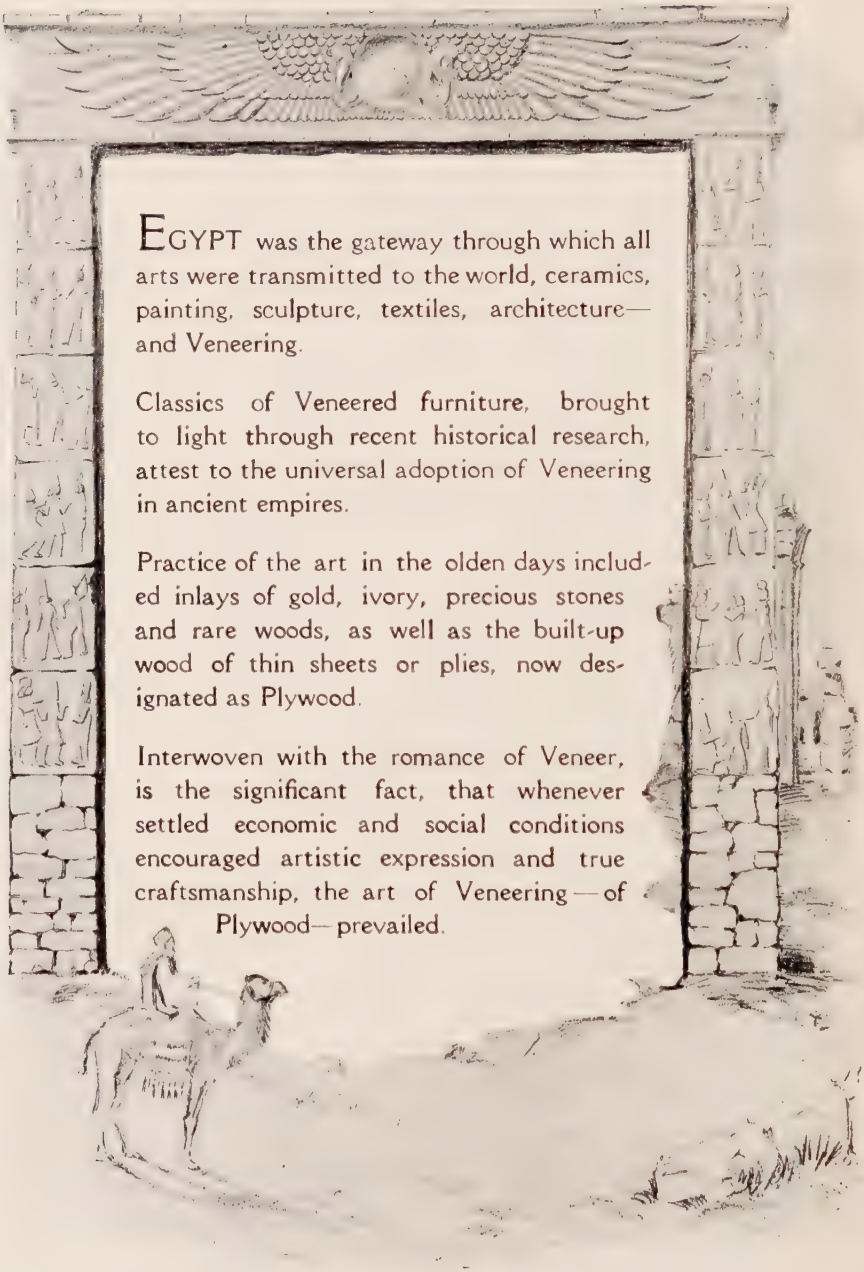
# VENEERS AND PLYWOOD

## PART I

## HISTORY OF VENEERS AND OF PLYWOOD



EGYPT was the gateway through which all arts were transmitted to the world, ceramics, painting, sculpture, textiles, architecture—and Veneering.

Classics of Veneered furniture, brought to light through recent historical research, attest to the universal adoption of Veneering in ancient empires.

Practice of the art in the olden days included inlays of gold, ivory, precious stones and rare woods, as well as the built-up wood of thin sheets or plies, now designated as Plywood.

Interwoven with the romance of Veneer, is the significant fact, that whenever settled economic and social conditions encouraged artistic expression and true craftsmanship, the art of Veneering—of Plywood—prevailed.

# CHAPTER I

## EVIDENCE OF THE USE OF VENEERS IN EARLIEST CIVILIZATION

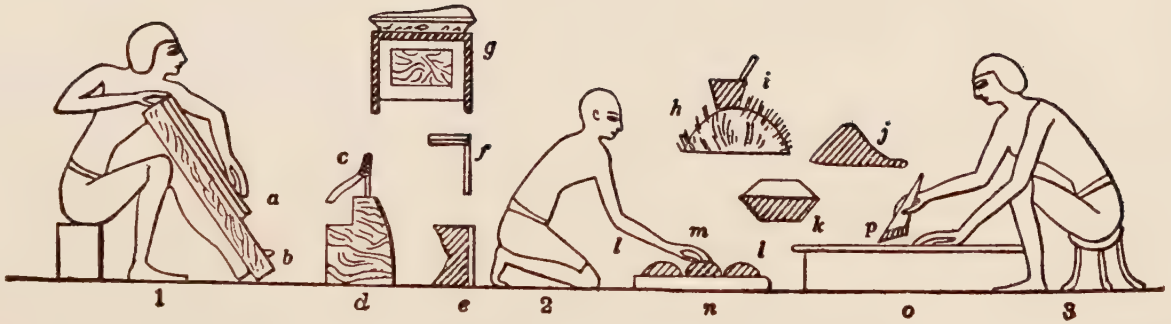
### Egyptian

Intensely interesting, not only as heritages from the founders of western civilization, but as proof that veneer and the art of veneering had their origin more than thirty-five centuries ago, are the existing specimens of Egyptian furniture, plywood built, which have survived the long period of oblivion.

Throughout the ages since the 15th and 14th Centuries preceding the Christian era, this work has been preserved. Closed to succeeding generations, Egyptian tombs have been opened to the modern world through scientific research by societies and governments only within the last century. The examples found stand as mute testimony to the skill and artistry of those early craftsmen who made fine veneered furniture for Rameses, Thothmes, Tutankhamen and Pharaohs of lesser fame.

Like the Pyramids, which have withstood the ravages of time and the beatings of wind-driven sand during many centuries, this early Egyptian furniture, veneered and inlaid, is a source of absorbing interest and curiosity to modern makers, who would find the work impossible without the highly developed appliances and machinery of the present day.

Little is known of the methods used—how the wood was sawed into sheets; how a glue, which despite some 3,500 years still holds thin layers of face wood to the heavier base or core, was prepared—but the work has endured and speaks for itself. That "artistic feeling and the skilled hand more than compensated for inferiority of tools" is the explanation of one authority.




VENEERING AND THE USE OF GLUE. *Thebes.*

*a*, a piece of dark wood applied to one of ordinary quality, *b*.
*c*, adze, fixed into a block of wood of the same colour as *b*.
*e*, a ruler; and *f*, a right angle, similar to those used by our carpenters.
*g*, a box. *i*, a glue pot on the fire. *j*, a piece of glue.
*Fig.* 2 is grinding something. *Fig.* 3 is applying the glue with a brush, *p*.

Illustration 1. Mural Record of Veneering, discovered in the Sculpture of Thebes and dated as early as the time of the Third Thothmes.

Reproduced from line drawing in "The Manners and Customs of the Ancient Egyptians," by Sir J. Gardner Wilkinson.

Sir Gardner Wilkinson, a distinguished British archæologist, describes the process in his volume, "The Manners and Customs of the Ancient Egyptians." Illustration 1 is a reproduction of his line drawing of the mural record found in Thebes. Of his observations, Wilkinson writes:

> Veneering is noticed in the sculptures of Thebes, as early as the time of the Third Thothmes, and the application of a piece of rare wood of a red color to a yellow plank of sycamore or other ordinary kind is clearly pointed out. And in order to show that the yellow wood is of inferior quality, the workman is represented to have fixed his adze carelessly in a block of the same color while engaged in applying them together. Near him are some of his tools with a box or small chest, made of inlaid and veneered wood of various hues.[1]

In this cut may also be noted the glue pot over the fire and the stone cauls, on which are placed what we may reasonably assume to be bags of hot sand to serve as weights and to provide heat while the glue is setting—all of which may be accepted as conclusively proving that the art of constructing plywood was well understood even in those ancient times.

Those early Pharaohs ruled over lands in the fertile valley of the Nile, which were rich and prosperous. As they prospered, a higher civilization was developed, the natural consequence of which was a desire for comfort and ease, and finally a delight in beautiful things.

Stone was the most commonly used building material, while wood and metal were used in building the more artistic articles. However, all three of these, with ivory and precious stones as inlays, had been utilized in the making of furniture. As early as the 15th Century B.C., experience taught that wood, of all materials, was the easiest to work and had the greatest adaptability for graceful and luxurious furniture. Nothing,

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1 "The Manners and Customs of the Ancient Egyptians," by Sir J. Gardner Wilkinson. Published by John Murray, London, 1878, Vol. II, p. 198. Reference is also made to this decoration in "The Life of Rekmara," by Percy E. Newbury. Published by Constable & Co., London, 1900.

during the ensuing 3,500 years, has been found to equal it. But the country produced little wood suitable for ornamental purposes, with the exception of the date and doom palms, the sycamore, tamarisk and acacias. Therefore, rare woods were imported from India—ebony, certainly, and perhaps rosewood and teak.

The Egyptians, desirous in each succeeding dynasty of surpassing the former in regal splendor, discovered that a piece of furniture could be beautified by means of a veneer of richly figured wood applied to an ordinary and serviceable wood.

An idea of the costly furnishings surrounding royalty is suggested by Georges Perrot and Charles Chipiez, in their "History of Art in Ancient Egypt":

> The interior of an ancient Egyptian house must have been very different from the bareness which greets a visitor to the modern East. Chairs with or without arms, tables of varied form, folding seats, foot-stools, brackets, supporting vases of flowers, cabinets, in which objects of value were locked up, filled the rooms. The upper classes of Egypt lived a life that was refined and elegant as well as civilized. A great lord of the time of a Thothmes or a Rameses was not content, like a Turkish bey or pacha, with a divan, a few carpets and a mattress, which after being locked up in a cupboard during the day is spread upon the floor for his accommodation at night. He had his bedstead, often inlaid with metal or ivory, and, like a modern European, he had other articles of furniture besides.
>
> Several pictures are extant in which Egyptian receptions or salons are represented. The company is not crouched upon the earth, in modern Oriental fashion. Both men and women are seated upon chairs, some of which have cushioned seats.[2]

The richness of some of these seats may be guessed from the chairs reproduced in Illustrations 2 and 3. The backs have elaborate figure work set upon and inlaid in the veneer and

[2] "A History of Art in Ancient Egypt," from the French of Georges Perrot and Charles Chipiez. Translation published by Chapman & Hall, Ltd., London, 1833, Vol. II, p. 42.

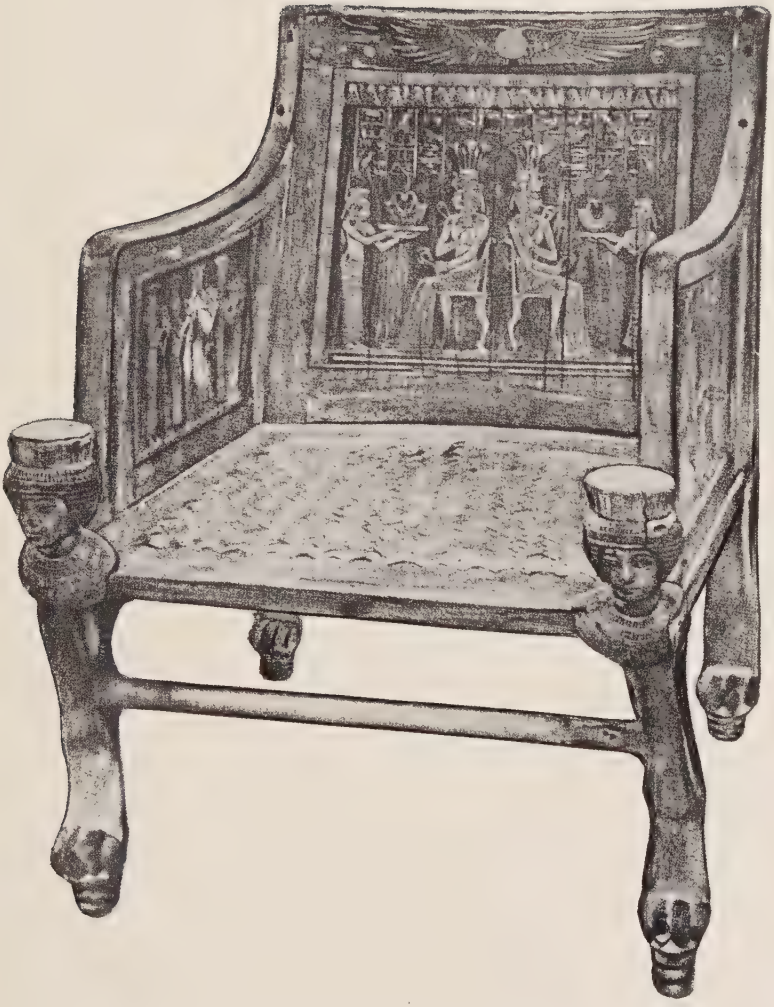

Illustration 2. Inlaid Egyptian Chair of Princess Sitamon, 14th Century, B.C., found in the Tomb of Iouya and Touya. The carved heads are portraits of the Princess, whose likeness appears also on the back of the chair. Now in Cairo Museum.

Courtesy, Dean-Hicks Co., publishers of "Decorative Furniture," by George Leland Hunter.

Illustration 3. Ancient Egyptian Chair of child's size, now in Cairo Museum. The back has elaborate figure work set upon and inlaid in the veneer.

Courtesy, Dean-Hicks Co., publishers of "Decorative Furniture," by George Leland Hunter.

are obviously the originals of the Empire style of chairs. In the Museum of the New York Historical Society may be seen ancient Egyptian chairs with circular inlays of bone and ebony; the British and Cairo Museums have other examples.

From a minute examination of the hundreds of elaborate color plates in a set of twenty-four Egyptian folios, which the Louisville (Kentucky) Public Library is so fortunate as to possess, it appears that many of the fine surfaces were veneered and that plywood construction was extensively used.[3]

> Boxes, chairs, tables, sofas, and other pieces of furniture were frequently made of ebony, inlaid with ivory, [says Wilkinson.]
>
> Sycamore and acacia were veneered with thin layers, or ornamented with carved devices, of rare wood, applied or let into them.[4]

Two conditions have contributed to the preservation of a more complete record of the work of Egypt than of many later nations and made it possible for the student of today to see the handiwork of thirty-five centuries ago: a climate of extraordinary dryness and the religious belief in a life after death, similar to man's earthly existence. In anticipation of human requirements in the new life so confidently expected, household goods and all the necessities of daily life were grouped about the sarcophagus. Such of those articles as were made of wood, many of them of plywood construction, have been found in a state of perfect preservation by excavators who have counted it the supreme moment of a lifetime to come upon a new tomb.

The most important discoveries, from the point of view of furniture, have had their source in the tombs of Iouya and Touya and Tutankhamen. The newly found treasures of "King Tut" have led to a revival of interest in things Egyp-

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[3] These folios are the official French depository of the findings of the savants and archæologists who accompanied Napoleon's famous military expedition to that ancient land and found among other treasures the Rosetta stone (now in the British Museum) which has furnished the key to the hieroglyphics of the monumental writings and history.

[4] Wilkinson, p. 195.

tian, and careful study and research have revealed astounding facts in the origin and history of veneers and of plywood.

It is interesting to study the bed now in the Cairo Museum, shown in Illustration 4, which was found in the tomb of Iouya and Touya, the great-grandparents of the wife of Tutankhamen. The headboard of this famous piece is clearly plywood built, with veneered panels and inlay. There is something startlingly modern in the design of the bed with its long, sweeping lines. The couch plane is slightly curved, however, instead of having the perfect levels of today. The headboard veneering is of laburnum wood and acacia, lavishly inlaid with jewels, gems, ivory and gold.

Fine and beautiful caskets, used for burial of ancient Egyptian kings, queens and members of the royal family, were veneered.

In the Ninth Egyptian Room of the Metropolitan Museum of Art in New York, may be found a particularly fine coffin of the period of the Twelfth Dynasty, in which was buried Nephthys, daughter of an Egyptian monarch. This casket is veneered—plywood construction throughout. (See Illustration 5.)

A further survey finds other examples of the cabinet-maker's art which have endured through the ages, showing pronounced taste for inlay. A folding stool has carved legs with inlays of ivory to assist the design; a redwood stool is inlaid with ivory and ebony. Panels of chests are enriched with paintings, or inlaid with precious woods, ivory, silver or enamel plaques.

Illustration 6 shows a large cedar-wood casket, the prototype of the modern traveling box or trunk, inlaid and veneered with ebony and ivory, which was found in the tomb of Tutankhamen. The casket has sliding poles by which to carry it, fixed in staples on the bottom.

Boxes were veneered with various woods. Others were of ebony, inlaid with ivory. The cabinet and embroidery stands

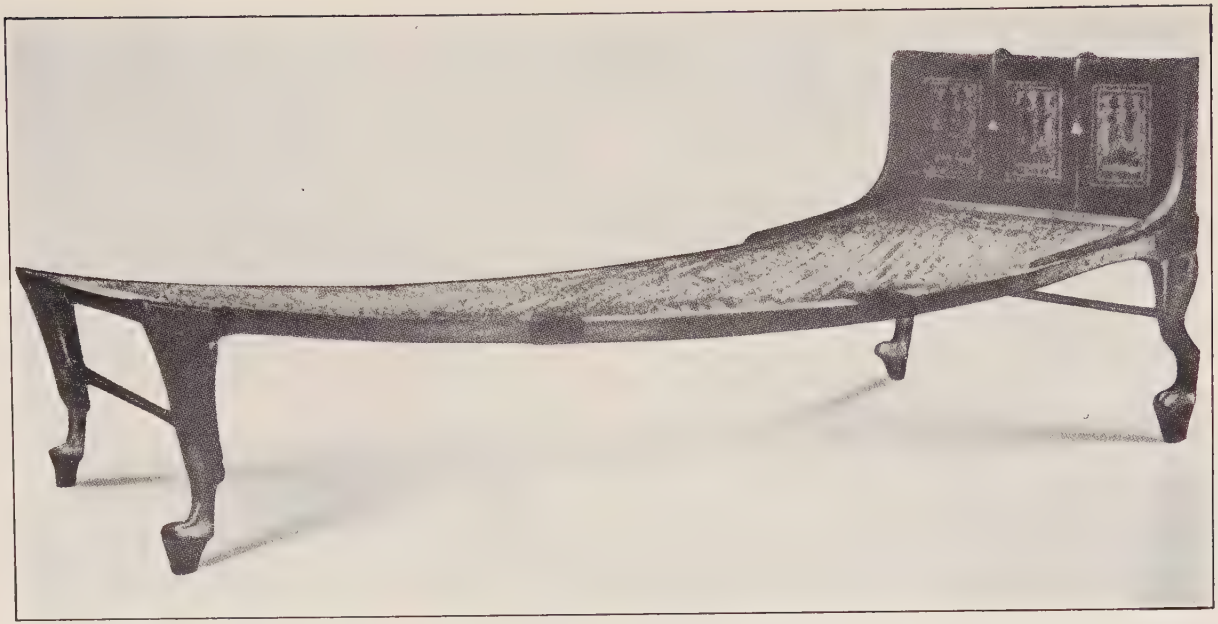

Illustration 4. Egyptian Bed with lion legs, 14th Century, B.C., found in the Tomb of Iouya and Touya, great-grandparents of the wife of Tutankhamen.

Courtesy, Dean-Hicks Co., publishers of "Decorative Furniture," by George Leland Hunter.

Illustration 5. Veneered Coffin of Nephthys, daughter of an Egyptian Monarch, period of the 12th Dynasty. Now in the Ninth Egyptian Room of the Metropolitan Museum of Art, New York.

belonging to the queens of Egypt were beautifully veneered, and inlaid with rare woods, gold and lapis lazuli, showing the handicraft of master artisans. (See Illustration 7.) Jewel caskets, tables, and even the corner posts of various creations "employed the art of ennobling an ordinary wood by gluing on thin layers of costly woods."

Burgess pays tribute to the civilization of Egypt in these words:

> The artists of Egypt understood painting, turning, inlaying, veneering and cane work, and they were by no means far behind craftsmen who achieved fame in those arts thousands of years later.[5]

## Babylonian and Assyrian

The growth of a pride in valuable possessions, as historians cited of Egypt, was predicated on the advancement of art, which followed the march of civilization. As nations progressed from the transition state succeeding barbarism, an appreciation of art was a natural development.

Babylonia and Assyria, among the first of the ancient world to reach a definite stage in civilization, early followed in the advancement of art the example of their neighbors to the south, along the Nile. The influence of the Egyptians was the stronger in national character because so little had been absorbed from invading peoples. Love for the decorative and the beautiful, in the valleys of the Euphrates and the Tigris, is exemplified in the domestic settings and furnishings. Inlays and overlays of veneers of wood, metals and precious and semi-precious jewels and stones were much in evidence for the adornment of furniture.

The Assyrian "knew how to make ingenious and skilful use of the materials he had," is the comment of the authors of "History of Art in Chaldea and Assyria." To quote further:

[5] "Antique Furniture," by Fred W. Burgess. Published by G. P. Putnam's Sons, New York, 1915, p. 29.

> Bronze and wood were not the only materials used in these objects of regal luxury. As in the throne of Solomon, the glory of gold and the creamy whiteness of ivory were mingled with the sombre tones of bronze. This is proved by the throne from Van, and it was noticed by the explorers of the Assyrian ruins; small fragments of ivory were mixed with the pieces of bronze that have been recognized as the debris of furniture. Some pieces of rock-crystal, found in the palace of Sennacherib, appear also to have helped to ornament a chair.
>
> It is easy to guess how ivory was used on these objects. . . . The cross-bars and uprights are divided into numerous small panels or divisions; each panel may have inframed a plaque of carved ivory.
>
> . . . . Some of the ivories were imported; but we believe that to have been the exception rather than the rule. We know both from the sculptured reliefs and from actual finds that ivory was brought into Assyria in its rough state. . . . Hence, it appears probable that ivory was worked at Nineveh and Babylon.[6]

Sir Austen Layard, whose excavations have thrown much light upon domestic life in Nineveh remarks that Assyrian furniture is characterized by greater massiveness than that of Egypt, and is ornamented with the heads of lions, bulls and rams. He observes that treatment of figures was more clumsy and rigid, and finally, of distinct interest from a veneering standpoint, that "their tables, thrones and couches were made both of metal and wood and probably inlaid with ivory."

No furniture of either Babylonia or Assyria has so endured the centuries as to furnish examples of the work of craftsmen of those countries. The climate did not contribute to the preservation of wood, as in Egypt. Furthermore, the palm and the poplar, the only native trees from which any considerable lengths could be cut, did not withstand exposure.

Visual evidence of their native art may be found only in

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[6] "A History of Art in Chaldea and Assyria," from the French of Georges Perrot and Charles Chipiez. Translation published by Chapman & Hall, Ltd., London, 1884, Vol. II, pp. 319, 320.

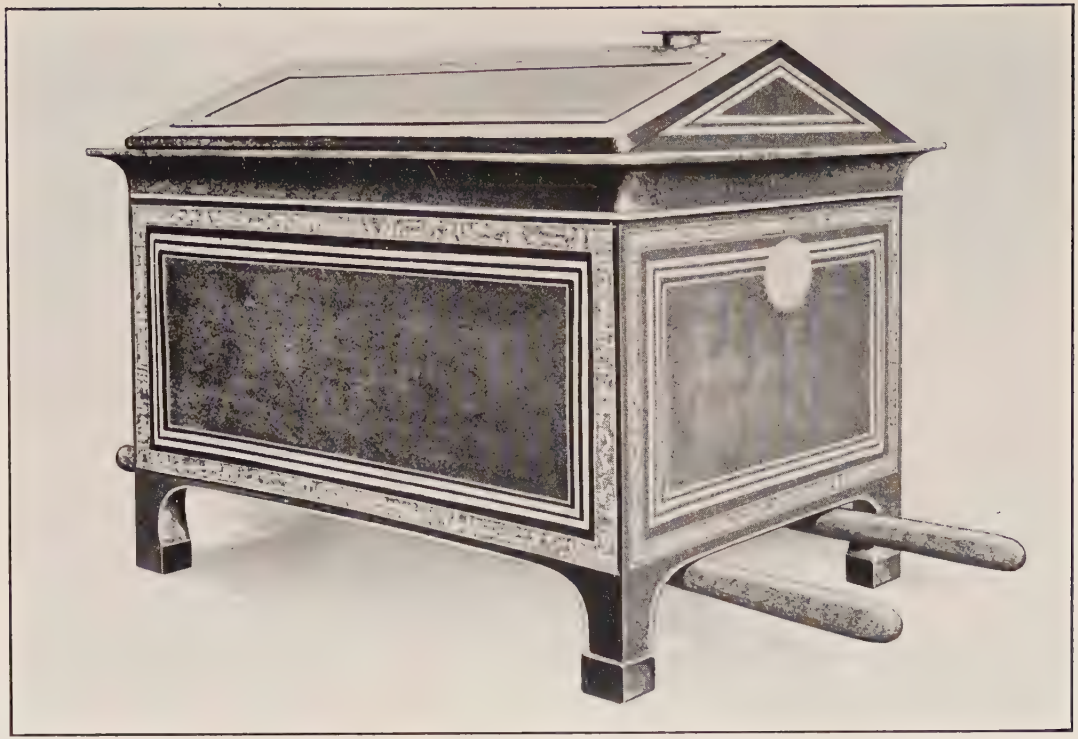

Illustration 6. Large Cedar-Wood Casket inlaid and veneered with ebony and ivory, showing sliding poles by which it was carried.

Courtesy, George H. Doran Co., publishers of "The Tomb of Tutankhamen," by Howard Carter and A. C. Mace.

Illustration 7. Embroidery Stand inlaid with ivory, period of the 18th Dynasty.

alabaster bas-reliefs, statuary, paintings and seals or cylinders, which have been recovered from ruins of ancient Biblical cities. In these records, writers of history and art note inlay and veneering as conspicuous decorative features of many pieces of furniture.

Perrot and Chipiez note the following, from their study:

> The princes and nobles of Assyria seem to have had a peculiar love for luxurious furniture. To see this we have only to look at the bas-reliefs. . . . Wood alone could have been used; metal would be too heavy, if solid, and not stiff and firm enough, if hollow. . . . Objects of regal luxury showed great variety in form and decorative motifs. Ivory helped to ornament articles of furniture. . . . In beds, tables, chairs and foot-stools, the framework was of wood.[7]

"Cedars of Lebanon," celebrated both in history and poetry of the East, were imported and much favored by the Assyrians, according to Burgess, who goes on to say of the overlay and inlay of Biblical times:

> In Nineveh and Judea, at the time of King Solomon, ebony, teak and Indian walnut were used, and they were frequently overlaid and inlaid with ivory. Biblical records of the furniture of Judea are especially interesting. Solomon is said to have possessed a bed of cedar wood, with pillars of silver and a golden bottom. The furnishings of a homely residence in the time of the prophet Elisha are recorded in scripture, for Elisha was provided with a bed, a chair, a table and a lamp in the guest chamber in which he was entertained.[8]

In Solomon's Temple, as described in the Scriptures, there were posts of the fir tree, whereon were carved cherubims and palm trees and open flowers overlaid with gold, fitted upon the carved work. The floor had three rows of hewed stone and a row of cedar beams.

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[7] Perrot & Chipiez, Vol. II, pp. 313, 314, 323.
[8] Burgess, p. 30.

> Moreover the king made a great throne of ivory, and overlaid it with the best gold.[9]

According to Frederick Litchfield's "Illustrated History of Furniture":

> The first well-known reference to wood work is to be found in Genesis, in instructions given to Noah, and from specific directions, we gather that mankind had acquired at a very early period a knowledge of different kinds of wood and the use of tools.[10]

To quote further from the same authority:

> Of ancient Hebrew furniture, there are unfortunately no trustworthy descriptions, but we may take it for granted that as the Jews and Assyrians came from the same stock, such ornamental furniture as there was, with the exception of figures of men or animals, would be of a similar character.[11]

The following is the contribution of John Hungerford Pollen:

> In Judea, as in other eastern lands, it is, and no doubt always has been, simpler than in the West, as so much of daily life is spent in the open air. Beds made of wood, inlaid with ivory and gold, are mentioned as early as the 13th Century B.C., and the prophet Amos (9th Century) censures the rich for using such beds. Ordinary beds, if used at all, were merely couches. In the figurative language of the Canticles, the bed of Solomon is of cedar of Lebanon, the pillars of silver and the bottom of gold.
>
> Of the ordinary chairs of the ancient Jews, nothing is known, and their tables are conjectured to have been metal or leather trays on low stands.
>
> It is not unreasonable to suppose that the furniture of the Hebrews was made by foreign workmen, or that the Hebrews themselves borrowed freely the forms and modes of

[9] I Kings X: 18.

[10] "Illustrated History of Furniture," by Frederick L. Litchfield. Published by Truslove & Shirley, London, 1892, p. 1.

[11] Litchfield, p. 2.

decoration of surrounding nations, such as the Egyptians and Assyrians.[12]

In the prophecy of the wreck of the good ship Tyre of Ancient Phoenicia, named for the city which was known as "the queen and mistress of the Mediterranean," we read of the fir trees of Senir; cedars from Lebanon in abundance to make masts; oars from oaks of Bashan; and benches of ivory brought out of the isles of Chittim.[13]

## Greek

Classic revivals have drawn upon the art forms of the ancient Greeks to such an extent that their decorative motifs and principles of style are already familiar.

Practically no vestiges of Greek furniture remain, but sculptures and the paintings of proud old Athens and reliefs in marble and terra cotta denote characteristics, both in furniture and architecture, very different from those of Egypt. The celebrated painted vases, a representative collection of which is displayed in the British Museum, give accurate pictures of the life of the time, in which furniture figured prominently for its beauty and utility. These combined evidences indicate that veneering was used for adornment, but evidently to a lesser degree than in Egypt.

The effect of contemporary nations upon Greece is not doubted by Pollen, who bears in mind, in picturing the furniture of the early Greeks, "the close connection which that people must have had with the Asiatic races and the splendor and refinement that surrounded the wealthy civilization of the oriental monarchies." He continues:

> The Greeks were so continually the allies or the rivals of the various states in Asia Minor, and pushed out into that

[12] "Handbook on Ancient and Modern Furniture and Woodwork," by John Hungerford Pollen, Rev. Ed. Published by Wyman & Sons, Ltd., London, 1908, Vol. I, pp. 28–30.

[13] Ezekiel XXVII: 6.

> fertile region so many vigorous colonies, that it cannot be doubted that the splendid stuffs, beds, couches, thrones, chariots and other objects used by Greeks on the Asiatic continent or in Europe had much of eastern character in form and method of execution and perhaps at first in decoration also.[14]

"Greek houses were probably very bare of furniture, according to our notions," Whibley is quoted as saying in his "Companion to Greek Studies." [15] And Pollen surmises that "these early pieces of furniture were probably executed in wood, and metal was at first but rarely used."

We know, however, that plywork was familiar to metallurgists at a very early time, through Homer's account of the forging of the shield of Achilles:

> First fashioned he a shield great and strong, adorning it all over. . . . Five were the folds of the shield itself; [Hephaistos threw in bronze, brass, tin and precious gold and silver] and therein fashioned he much cunning from his wise heart.[16]

Wooden furniture was frequently inlaid with glass, ivory and metal plates. Beds of wood were sometimes ornamented in tortoise-shell and veneers of fine wood.

In Book 23 of the Odyssey, Ulysses, describing to Penelope the bride-bed which he had made, says: "Beginning from this head-post, I wrought at the bedstead till I had finished it, and made it fair with inlaid work of gold and of silver and of ivory."

"The bars and frames of chairs and the footstools and pedestals used in Greece were often of cedar wood, inlaid with carved ivories," according to Burgess. Caroline Louise Ransom, also, finds "positive indications of the large use made of wood in the construction of Greek beds."

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[14] "Ancient and Modern Furniture and Woodwork," by John Hungerford Pollen. Published by Chapman & Hall, London, 1875, p. 10.

[15] Pollen quoting Whibley, p. 357.

[16] Homer's "Iliad," Book XVIII. Andrew Lang translation. Published by Vincent Parke & Co., New York, 1909.

We read further:

> Some wooden couches were enriched with other materials. Chief among these was ivory. Tortoise-shell, gold, silver and bronze may have been among accessory materials sometimes used on beds of wood. Wooden couches were probably sometimes beautified by veneers of finer woods, such as box.[17]

Pollen, in his Handbook on "Ancient and Modern Furniture and Woodwork," declares:

> Large and solid chests and presses were commonly used for storing clothes and household linen and smaller boxes were employed for toilet requisites, papers and other articles. They were often elaborately decorated with floral ornament, figure subjects and other devices, sometimes, with mythological and legendary scenes.[18]

Litchfield gives a description of the famous chest in which Cypselus of Corinth was concealed which is "said to have been made of cedar, carved and decorated with figures and bas-reliefs, some in ivory, some in gold or ivory, part gilt and inlaid on all four sides and on the top.[19]

A forerunner of "overlay" may be seen in the panel of a couch described by Miss Ransom as having "high-relief decoration, in which each figure is to be understood as carved out of a separate piece of wood and fastened with wooden dowels to the back-ground." [20]

This conclusion of Pollen is enlightening:

> The woodwork and furniture of the Greeks were decorated with characteristic beauty and taste, the methods employed being painting, carving, turning and inlaying and incrusting with metals, ivory and other precious substances;

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[17] "Studies in Ancient Furniture," by Caroline Louise Ransom. Published by University of Chicago Press, Chicago, 1905, pp. 40–41.

[18] Pollen's Handbook, p. 35.

[19] Litchfield, p. 11.

[20] Ransom, p. 47.

these forms of ornamentation were sometimes used separately, and sometimes together. In the earlier and purer period of Greek history, when the private life of the citizen was very simple, the decoration was confined chiefly to temples and public buildings, but in later times, great luxury became general.[21]

## Roman

In marked contrast to the simplicity of home furnishings in very early Greece, where the finest that art could produce was dedicated to the service of the nation, is the magnificence and highly ornamented style of Roman private possessions.

Only such furniture as was made of stone and metal has come down to us; consequently, secondary sources of information must be relied upon.

Writers on ancient furniture declare that love of comfort was subordinated to admiration of costly materials, fine workmanship and artistic forms, and in the line of ornamentation that veneering was not only universal but of superlative quality and excellence. Here is the first evidence that veneer was used on an extensive scale for door frames and panels. The Romans loved the beautiful effects of "cross-cut veneers"; some of their table tops resembling "the spots of the leopard," others, "a swarm of bees," some, the "tawny lion," or the "stripes of the tiger."

Litchfield writes of the time of Augustus (63 B.C.–A.D. 14):

> Roman furniture of the time was of the most costly kind. The chief woods used were cedar, pine, elm, olive, ash, ilex, beech and maple. Ivory was much used.
>
> . . . . Veneers were cut and applied, not as some have supposed for the purpose of economy, but because by this means the most beautifully marked or figured specimens of the woods could be chosen, and a much richer and more

[21] Pollen's Handbook, p. 36.

decorative effect produced than would be possible when only solid timber was used.[22]

Pollen describes ornamental woodwork of sumptuous Roman houses which was rich in the extreme. He tells us of inlaid door frames and ceilings in which "the timbers were covered with boards and formed into coffers and panels, painted, gilt and inlaid with ivory." [23]

The important article of furniture in the Roman house was the table, the most costly being the round tables made from the wonderfully marked cross-sections of the citrus tree found in Africa. The chief value of this wood lay in the beautiful lines of the fibres and the veins, but the color was also a factor —that of wine mixed with honey being most highly esteemed. In the words of the Roman naturalist, the elder Pliny:

> The citrus tree gave rise to a mania for fine tables, an extravagance with which the women reproach the men, when they complain of their vast outlay upon pearls. Notwithstanding his moderate means, Cicero gave no less than one million sesterces, (conservatively estimated at $20,000) for a veneered table of citrus wood.[24]

We also have Pliny's historical statement of almost 2,000 years ago that the proudest possession of Caesar was a table, beautifully veneered.

"Although not employed to such an extreme extent as for tables, costly woods, probably in the form of veneers, were not unusual in expensive couches," writes Miss Ransom. "Couches which were veneered completely or nearly so with ivory were very popular. Tortoise-shell was also used. Wood, not combined with other materials, no doubt continued to be used considerably for common couches." [25]

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[22] Litchfield, pp. 12–13.

[23] Pollen, p. 21.

[24] Pliny's "Natural History," Book XIII. Bostock & Riley translation. Published by Bohn, London, 1855–1857.

[25] Ransom, p. 55.

a method by which the saw-dust is discharged. The ash is found the most pliable wood of all for working; and, indeed, for making[49] spears it is better even than the hazel, being lighter than the cornel, and more pliable than the wood of the service-tree. The Gallic variety is so supple, that it is employed in the construction of vehicles even. The elm would rival the trunk of the vine[50] for some purposes, were it not that its weight is so much against it.

CHAP. 84.—VENEERING.

The wood, too, of the beech is easily worked, although it is brittle and soft. Cut into thin layers of veneer, it is very flexible, but is only used for the construction of boxes and desks. The wood, too, of the holm-oak is cut into veneers of remarkable thinness, the colour of which is far from unsightly; but it is more particularly where it is exposed to friction that this wood is valued, as being one to be depended upon; in the axle-trees of wheels, for instance; for which the ash is also employed, on account of its pliancy, the holm-oak for its hardness, and the elm, for the union in it of both those qualities. There are also various workman's tools made of wood, which, though but small, are still remarkably useful; in this respect, it is said that the best materials for making auger handles are the wild olive, the box, the holm-oak, the elm, and the ash. Of the same woods also mallets are made; the larger ones, however, are made of the pine and the holm-oak. These woods, too, have a greater degree of strength and hardness if cut in season than when hewn prematurely; indeed, it has been known for hinge-jambs, made of olive, a wood of remarkable hardness, after having remained a considerable time on the spot, to put out buds[51] like a growing plant. Cato[52] recommends levers to be made of holly, laurel, or elm; and Hyginus speaks highly of the yoke-elm, the holm-oak, and the cerrus, for the handles of agricultural implements.

The best woods for cutting into layers, and employing as a

[49] See c. 24.

[50] Fée thinks, from the context, that the meaning is, that the vine was employed in the construction of chariots; it depends entirely on the punctuation adopted.

[51] This could only have happened in the first year that they were so employed.

[52] De Re Rust. c. 31.

Illustration 8. Photostated copy of Chapter on Veneering, Book

veneer for covering others, are the citrus, the terebinth, the different varieties of the maple, the box, the palm,[53] the holly, the holm-oak, the root of the elder, and the poplar. The alder furnishes also, as already stated,[54] a kind of tuberosity, which is cut into layers like those of the citrus and the maple. In all the other trees the tuberosities are of no value whatever. It is the central part of trees that is most variegated, and the nearer we approach to the root the smaller are the spots and the more wavy. It was in this appearance that originated that requirement of luxury which displays itself in covering one tree with another, and bestowing upon the more common woods a bark of higher price. In order to make a single tree sell many times over, laminæ of veneer have been devised; but that was not thought sufficient—the horns of animals must next be stained of different colours, and their teeth cut into sections, in order to decorate wood with ivory, and, at a later period, to veneer it all over. Then, after all this, man must go and seek his materials in the sea as well! For this purpose he has learned to cut tortoise-shell into sections; and of late, in the reign of Nero, there was a monstrous invention devised of destroying its natural appearance by paint, and making it sell at a still higher price by a successful imitation of wood.

It is in this way that the value of our couches is so greatly enhanced; it is in this way, too, that they bid the rich lustre of the terebinth to be outdone, a mock citrus to be made that shall be more valuable than the real one, and the grain of the maple to be feigned. At one time luxury was not content with wood; at the present day it sets us on buying tortoise-shell in the guise of wood.

CHAP. 85. (44.)—THE AGE OF TREES. A TREE THAT WAS PLANTED BY THE FIRST SCIPIO AFRICANUS. A TREE AT ROME FIVE HUNDRED YEARS OLD.

The life of some trees might really be looked upon as of infinite[55] duration, if we only think of the dense wilds and

[53] It is singular. Fée says, to find the wood of the palm, and that of the poplar, which are destitute of veins, enumerated among those employed for veneering.

[54] In c. 27.

[55] According to Adanson, the baobab will live for more than six thousand years.

XVI of Pliny's Natural History, written in the 1st Century, A. D.

Pollen declares:

> Veneering was universal in wood furniture of a costly kind. The slices of wood were laid down with glue as in modern work. Figwood, willow, plane, elm, ash, mulberry, cherry, cork wood, were amongst the materials for the bed or substance on which to lay such work. Wild and cultivated olive, box, ebony (Corsican especially); ilex, beech were adapted for veneering boxes, desks and small work. Besides these, the Romans used the Syrian terebinth, maple, palm (cut across), holly, root of alder, poplar, horn; ivory, (plain and stained) tortoise-shell; and wood grained in imitation of various woods for veneering couches and other large pieces of furniture; as well as door frames, etc., so that this imitation of grains is not entirely a modern invention. Woods were soaked in water or buried under heaps of grain to season them; or steeped in oil of cedar to keep off the worms.[26]

Pliny in his "Natural History" indicates his admiration for the art of veneering in the preceding section, which is reproduced by photostat from a translation of the original. (See Illustration 8.)

## Oriental

From earliest days, furniture of the Orient has been ornate in detail, and the "inlays of ivory upon wood, elaborate and beautiful geometrical designs, are still produced in much the same fashion as in the Middle Ages," according to Jackson.[27] But the field offers less than the Egyptian and the Roman, to the study of veneers and of plywood.

Manners and customs of the ancient East occasioned the use of little furniture, as it was the habit, everywhere but in China, to squat upon rugs or cushions on the floor and to have food served from low stands or trays.

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[26] Pollen, p. 33.

[27] "Intarsia and Marquetry," by F. Hamilton Jackson. Published by Sands & Co., London, 1903, p. 8.

The Chinese, however, one of the most ancient of surviving Asiatic civilizations, out of their national customs, developed an individual art. They designed chairs and other pieces, which were not only comfortable but admirable in construction. In the 15th and 16th Centuries, handsome cabinets were made of lacquered wood, enriched with ivory, mother-of-pearl, silver and gold. Their furniture of so recent a date as the 18th Century is described as follows: "Elaborate bedsteads, tables and cabinets were also made with panels of ash stained a dark color and ornamented with hunting scenes in which the representations of men and horses are of ivory, or sometimes with ivory faces and limbs, and the clothes chiefly in a brown colored wood." [28]

It is clear, however, from the elaborate pieces prized in museums, that the most cherished work in decorated furniture of China and Japan is the beautiful lacquer work, so popular at the present writing. A vast degree of skill and patience is required in the process of lacquering, as sometimes eighteen or twenty treatments are necessary for a proper finish.

Reference is found to Indian tables of shishem wood inlaid with ebony and ivory. Large pieces of furniture were of carved teak and smaller ones of sandalwood in minutely cut design.

Of Persian specimens, it is difficult to find many important examples preserved. All that have endured the ravages of time are an occasional box or stool. The country produced little timber, except in the Caspian provinces. The Persian manner of decorating wood work was similar to that of the Indian, consisting of ivory or mother-of-pearl inlay in geometrical patterns upon brown wood, or a lacquer finish. Many small articles of Persian marquetry are inlaid on a ground of cedar-wood.

The arts of the Arabs were derived from the Persians, as were those of the Romans from the Greeks. It is unfortunate

[28] Litchfield, p. 127.

that the best features of Arabic civilization were ultimately destroyed by the Turks. The influence of their skill in manufacturing survived, however, in the impetus given to western Christian industries. Descriptions of Arabian pieces include a carved pulpit of the 15th Century which showed signs of ebony inlaid with ivory, a bedstead with inlay of ivory and a carved wood door of the 17th Century, the panelling of which was cedar, ebony and ivory.

The consummate patience of the Oriental for the handling of detail and his inherent taste for the harmony of colors are shown in the fine art of the weaving of a rug, ofttimes the labor of a lifetime. Through all time the best work has been inspired by devotion and not by the thought of gain.

The influence of the Orient upon art forms, during certain periods, is made manifest through tracing the development of furniture through the ages.

# CHAPTER II

## DISAPPEARANCE OF THE ART OF VENEERING IN THE MIDDLE AGES

The history of furniture types is so indelibly linked with the history of the customs and manners of various peoples that changes in styles can only be understood and appreciated by taking cognizance of the principal historical events effecting changes in the lives of the people of different periods.

Veneering is an art which can be practiced only under stable economic conditions, as it requires intricate tools and highly developed appliances. Therefore, it is not surprising that during the entire medieval period, a period of chaotic unrest, practically the only trace of woods used as inlays or veneers is seen in the style known as Byzantine, a mixture of Eastern and Roman elements, which centered about Constantinople.

A selection from Litchfield's "Illustrated History of Furniture" gives a résumé of events significant in furniture development of the period:

> Thus, we have during the space of time known as the Middle Ages, a stretch of some 1,000 years, dating from the fall of Rome itself, in A.D. 476, to the capture of Constantinople by the Turks under Mohamet II in 1453, an historical panorama of striking incidents and great social changes. It was a turbulent and violent period, which saw the completion of Rome's downfall, the rise of the Carlovingian family (Charlemagne,) the subjection of Britain by the Saxons, the Danes, and the Normans; the extraordinary career and fortunes of Mohamet; the conquest of Spain and a great part of Africa by the Moors; and the Crusades, which united in a common cause the swords and spears of friend and foe.

> It was the age of monasteries and convents, of religious persecutions and of heroic struggles of the Christian Church. It was the age of feudalism, chivalry and war, but toward its close, a time of comparative civilization and progress, of darkness giving way to the light which followed; the night of the Middle Ages preceding the dawn of the Renaissance.[1]

## Byzantine

"The gorgeousness and ostentation of Roman furniture was continued by the Byzantine Empire and chiefly through them transmitted to the rising nations of the West," according to Pollen.[2]

Very little furniture was produced, but to judge from the mosaics, ivory bas-reliefs and manuscripts of the period, ornament was an outstanding characteristic. Inlaid woods were employed, and ivory, both carved and inlaid, was much in use. As in ancient days, customs governed requirements, and now chairs displaced the couches, upon which the Romans had been wont to recline at table. Tables and beds continued in the Roman style.

As in the earlier civilizations, religious beliefs were reflected in the decoration of furniture. The Mohammedan religion forbade the use of human or animal forms, and consequently geometrical and floral designs prevailed. When Christianity came to be the accepted religion, ancient classic art was put aside and Christian symbolism substituted in the art forms.

A typical Byzantine piece which is classed as one of the most interesting relics of the Middle Ages is the "Chair of St. Peter," preserved among the priceless treasures of the Vatican in Rome. (See Illustration 9.) Richly veneered and inlaid with ivory and gold, it is now encased in bronze for protection. Before the discovery of the Egyptian pieces, it was

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[1] Litchfield, pp. 17–18.
[2] Pollen's Handbook, p. 4.

Illustration 9. "Chair of St. Peter," richly veneered and inlaid with ivory and gold. Now in the Vatican at Rome.

regarded as one of the oldest examples of wooden furniture in existence.

The most beautiful and perfect example of typical Byzantine architecture is St. Mark's Church in Venice.

## Gothic

When the Crusaders returned from the Holy Land, they had absorbed from the higher civilization of the East, standards of art and culture far superior to any hitherto known in Western Europe. Imbued with admiration for the Byzantine and Saracenic, they inspired a wholly new form of architecture and decoration.

In the art designated as Gothic, which dominated Western Europe in the 13th, 14th and 15th Centuries, line and composition express the tendency for life and motion. Characteristic ornament is derived directly from the life of the forest, as the tree springing from the ground, the branch from its trunk, the tendril from the vine—all aspiring skywards.

When the Gothic conception of style was applied to furniture, the product was crude and unwieldy in the extreme. It sufficed in its massive strength for the rough life of the times, but in no degree approached the standard of Gothic architecture which has commanded the admiration of all ages.

French. France in 1100 was really the origin of the Gothic style, and the Cathedral of Notre Dame, with its beautiful soaring twin towers, exemplifies its spirit in architecture and is one of the best known examples of the 12th Century. Ecclesiastical influence in the Middle Ages was so all-pervading that it controlled artistic expression. Motifs of religious significance became the rule and the leaf motif the variation. Many designs were taken directly from the tracery work of stained glass windows.

Gothic art was primarily an architectural art and the high-

pointed arches, perpendicular lines (or the familiar linen-fold substitute), Gothic columns and panelled carving were all repeated in the furniture. Indeed, the making of furniture was in the hands of the same carpenters who were doing the building. Serviceability rather than beauty of surface was its prime object, evident in the heavy oak and chestnut used.

From illuminated manuscripts, which comprise the only source of study of furniture design for many centuries, we note a general effect of massive strength, unvaried by the decorative touch of veneers. Utility, rather than beauty, was the motive and carving was the sole ornament. Heavy chests, some with mounts of iron, were indispensable, not only on the march but as articles of furniture, pressed into service at inns and sometimes in dwellings, as benches, tables, and even beds. Stools and benches were commonly used at one side of the dining-tables only, as the defenders of the household thought it wise to face the door. High-backed dressers displayed the plate in the more stately houses. Living rooms were furnished with "throne" chairs and with beds of the enclosed canopied variety, for protection against the cold.

In medieval times, the furniture of the main hall, used for eating, sleeping and general living, was much the same throughout Christian Europe.

English. Pollen states in his Handbook:

> The story of English furniture begins with the Anglo-Saxons, for under the long domination of the Romans, Britain was merely a Roman province and had no separate national existence. Of the rude and far-off times when the Celts occupied these islands there are not sufficient remains to enable one to gain a knowledge of the furniture they possessed, but the beauty of the few metal objects that have survived would lead one to surmise that it must have had great artistic merit.[3]

Prior to the Norman invasion, England was far behind

[3] Pollen's Handbook, p. 53.

the continental nations, in the fine arts, metallurgy only, excepted.[4]

In Britain, as in France, oak, of which the native forests yielded a plentiful supply, was the chief wood employed in the making of furniture. Planks for tables were rough hewn; beds were little better than raised wooden boxes. Only after years of the Norman reign was furniture made of well-seasoned lumber and rooms finished with panelling.

Specimens of wood work are extremely rare and consist principally of old chests and church pieces.

In feudal times, the rude manner of living required but primitive contrivances. Lack of permanence of possession of medieval castles rendered it necessary only that household possessions be few and strongly built to resist rough transportation. With peace among the feudal lords, the comforts of living increased, and the taste for luxuries grew with the establishment of security for property.

The one reference found to inlaying or veneering of this period appears in Scott's "Ivanhoe," in the description of the chairs used by the master and mistress of a Saxon castle and "to each of these was added a foot-stool curiously carved and inlaid with ivory, which mark of distinction was peculiar to them." Other members of the household sat upon rude benches, stools and settles.

ITALIAN. In Italy, Gothic influence was most marked in the 14th Century. Venice was attaining a position of wealth and power, but wood-carving rather than veneering was the art developed there. Gothic taste gained but slight hold in that country, which never really freed itself from the classic and Byzantine influences. There, according to Hunter, the term, Gothic, was used as a synonym of barbarous, because of the contempt that Italians of the Renaissance felt for a style

[4] Pollen's Handbook, p. 56.

that was non-Roman, imposed upon them by the invading Goths and Vandals.

In brief, during the medieval period, preceding the Renaissance, there prevailed practically a state of barbaric living when all arts—particularly the arts of veneer and of plywood—suffered eclipse.

# CHAPTER III

## FORMS OF VENEERING IN THE RENAISSANCE

### Intarsia in the Italian Renaissance

Furniture of the Italian Renaissance type is in great vogue at the present writing. For this reason and as it was the keynote and source of inspiration of subsequent styles, the study of this period is of intense interest. Also in the history of veneers and of plywood, the period takes an important place, because it brought the return of inlay as a form of decoration.

The words of Dyer give the setting:

> The Renaissance was a period marked by the revival of learning, a general emergence from the conditions of the Dark Ages, and new life in all branches of culture and art. This revival of learning produced a new interest in Greek and Roman antiquities. Peace, following long wars, reigned in Italy during this period and made it possible for the nobles and men of wealth to become patrons of the arts.
>
> The Renaissance movement was European in scope, but it had its beginning, focus, and highest development in Italy. New life was injected into almost every field of endeavor. There was a veritable outburst of intellectual energy, from which sprang discoveries, inventions, and the development and dissemination of ideas. . . . It was a natural, joyous, free feeling, expressed in every field, a liberation of ideas marked by originality and spontaneity, guided but untrammeled by the traditions of antiquity. The creative impulse was supreme; it was a Golden Age of achievement.[1]

Venice felt the Renaissance spirit about the end of the 13th Century. But the time commonly designated as the early Renaissance is the 15th Century and as the "high or classic"

[1] "Hand Book of Furniture Styles," by Walter A. Dyer. Published by Century Co., New York, 1918, pp. 11–12.

period, the 16th Century. The following century saw the style much overdone and inevitable decadence as the result.

In 1494, the Duke of Milan appointed as Director of Painting and Architecture in the Academy, Leonardo Da Vinci, a man of many-sided genius. His first administrative act was to banish the prevailing Gothic principles and to set up classic art as the model, freshened by recent discoveries of the stuccos of ancient Rome. In Florence, the genius of Brunelleschi is associated with the revival of classic art.

In the 16th Century, at the height of the Renaissance, art flourished under the patronage of the all-powerful de Medici family, when Leo X was Pope. The masterpieces of Michael Angelo, Raphael, Titian and Andrea del Sarto were executed at this time, when every encouragement was given to native artists and also to those who were sent as students to the Roman capital from the dominions of princes throughout all Europe.

With the growth of a national taste for beauty and ornamentation, came a corresponding increase in the elegance and luxury of home furnishings. The result was that elaborately designed and extravagantly large pieces of furniture were created to meet the demand.

Of inlay, we are told by Pollen:

> Many materials were employed by the Renaissance artists. Wood first and principally in making furniture, but decorated with gilding and painting; inlaid with agate, carnelian, lapis lazuli and mother-of-pearl; and with other woods.[2]

The heavy oak used in Gothic forms at a time when it was not possible to concede much to comfort or to beauty, was displaced by woods more suited to fine carving, walnut being the prime favorite. Pear, maple, pine and cypress also appear.

In addition to painting, gilding ornamentation and carving, which last became very intricate in design, inlay came to

[2] Pollen, p. 69.

be much used. Intarsia was the term given such decoration at this period.

Inlay, intarsia and marquetry, all three are forms of veneering. To inlay is "to decorate by inserting wood, ivory, tortoise-shell, etc., as into grooved or sunken patterns in furniture." Intarsia comes from the Latin word "interserere," to insert. It may be considered the practical equivalent of veneer, as in appearance the two are indistinguishable, although in some instances intarsia was inserted in the smoothed surface of a block of wood rather than in a thin sheet of veneer. Marquetry comes from the French word, "marqueter," meaning to spot, to mark.

Foley says in his "Book of Decorative Furniture":

> Perhaps the best definition of the difference between inlaying and marquetrie would be to describe inlay as patterning of various colored woods, let into the solid panel or groundwork of a piece of furniture, and marquetrie as patterning let into an equally thin groundwork, the complete work (both pattern and ground) then being applied to cover the surface to be decorated.[3]

Robinson makes this distinction:

> All three terms refer to processes which are very similar, as in each case woods of various kinds cut into thin slices are glued onto or into a thicker and cheaper ground work. . . . The distinctions of "inlay" and "marquetry" are not very strictly kept. The terms have a tendency to be used rather promiscuously, according to the amount of pattern in proportion to ground. Where very little ground shows, it is the practice to speak of marquetry, where the ground predominates, we use the term inlay.[4]

Hunter differentiates between them by explaining that the difference is principally geographical as "marquetry refers

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[3] "The Book of Decorative Furniture," by Edwin Foley. Published by G. P. Putnam's Sons, New York, 1911, Vol. I, p. 383.

[4] "English Furniture," by Frederick S. Robinson. Published by Methuen & Co., London, 1905, pp. 168–169.

primarily to the thin figured veneers made famous in France in the 18th Century; intarsia, to the Italian inlays of the Renaissance, and before; and inlay, to marquetry of the Elizabethan type."[5]

Much of the Italian intarsia is still to be seen in the beautiful old cathedrals of Florence, capital city of the Renaissance in the 15th Century. The pulpits, lecterns, choir stalls, and panels all bear evidence that neither time nor money was spared in obtaining the most elaborate of decorative effects for houses of worship.

F. Hamilton Jackson in "Intarsia and Marquetry" interestingly relates the manner in which the art was cherished, transmitted from master to apprentice and from father to son, and how the secrets of preparing certain colors were jealously guarded. He tells us that Siena was really "the cradle of Italian carving and inlaying," and that Antonio Barili, one of the best Sienese masters of the 15th Century, in his work on the choir of the Chapel of S. Giovanni, left a panel which shows the simple means used in intarsia work. Illustration 10, taken from Jackson's book, with the following extracts, shows Barili at work:

> His tools consist of a folding pocket-knife, a square-handled gouge, and a short-bladed, long-handled knife, which he holds with the left hand and presses his shoulder against so as to use the push of the shoulder in cutting, while in the right he holds a small pencil, with which he appears to direct the knife edge.[6]
>
> The early mode of working intarsia in Italy, where it is more than 100 years more ancient than in any other country, was by sinking forms in the wood, according to a prearranged design, and then filling the hollows with pieces of differently colored woods. At first the number of colors used was very small—indeed Vasari says that the only tints employed were black and white, but this must be interpreted

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[5] "Decorative Furniture," by George Leland Hunter. Published by the Dean-Hicks Co., Grand Rapids, Mich., 1923, p. 317.

[6] Jackson, p. 38.

freely, since the color of wood is not generally uniform and there would consequently often be a difference in tint in portions cut from different parts of the same plank.[7]

Illustration 10. 15th Century Intarsia in Italy, showing Antonio Barili at work, by himself.

Reproduced from "Intarsia and Marquetry," by F. Hamilton Jackson.

Litchfield writes of veneering at the end of the 14th Century:

> Makers of ornamental furniture began to copy marble mosaic work by making similar patterns of different woods. Subsequently this branch of industrial art developed, from such modest beginnings as the simple pattern of a star, or

[7] Jackson, p. 104.

bandings of different kinds of wood in the panel of a door, to elaborate picture making, in which landscapes, views of churches, houses and picturesque ruins were copied, figures and animals being also introduced. This work was naturally facilitated and encouraged by commerce between different nations, which rendered available a greater variety of woods. In some of the early Italian "intarsia," the decoration was cut into the surface of the panels, piece by piece.

As artists became more skillful, veneers were applied and the effect was heightened by burning with hot sand the parts requiring shading; and the lines caused by the thickness of the sawcuts were filled in with black wood or stained glue, to define the design more clearly.[8]

Ivory, in addition to wood, was revived as a material for inlay, and bone of a fine quality was frequently substituted when ivory became difficult to obtain.

Conventionalized forms were used everywhere, such as the classical columns and panels of symmetrical ornament.

To conform with its setting, Renaissance furniture was formal and almost palatial, rather than home-like and comfortable. It had an architectural quality and was notably fine in proportion.

Cabinet-making came to be a much respected craft, as new pieces were originated and customary forms remodelled to meet the demands of the more sumptuous manner of living. Hunter says of panels of the 15th Century enriched with intarsia:

Life, having become more settled, the chests became less movable and more luxurious. The panels of some were adorned with exquisite intarsia. . . . A royal development from the cassone (marriage chest) is the Florentine cassapanca, or chest-bench.[9]

Exquisite though simple and inexpensive in workmanship, are the sideboards and cabinets and desks and bookcases of the Italian Renaissance, often enriched with intarsia.[10]

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[8] Litchfield, p. 54.
[9] Hunter, p. 117.
[10] *Ibid.*, p. 119.

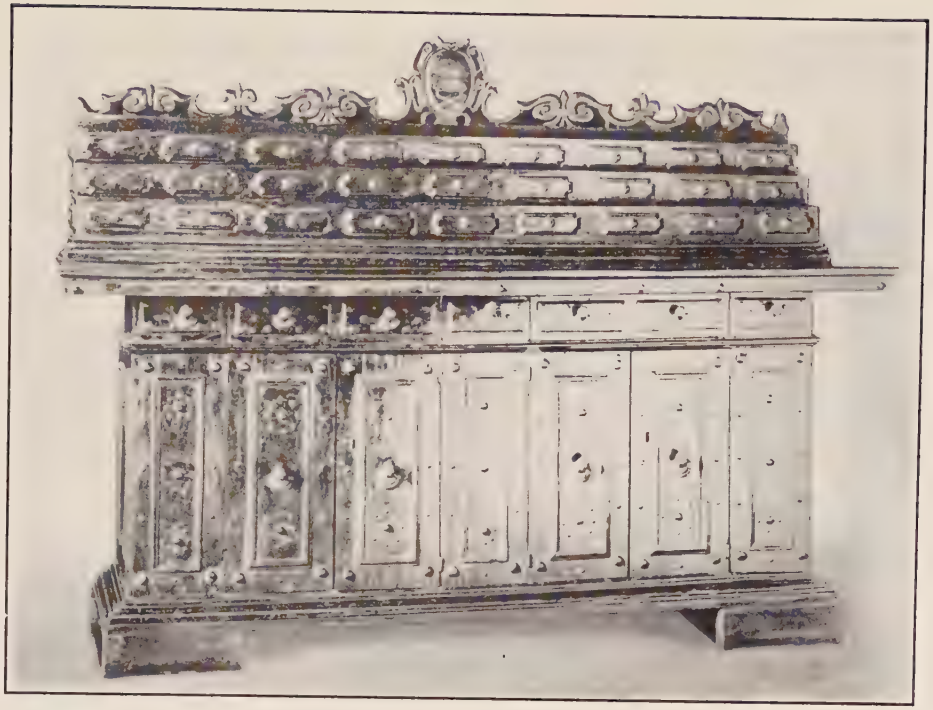

Illustration 11. 16th Century Florentine Credenza, showing evidences of veneer.

Courtesy, Doubleday, Page & Co., publishers of "The History of Italian Furniture from the 14th to the 19th Century," by William M. Odom.

The Florentine credenza photographed for Illustration 11 offers evidence of veneer in the 16th Century.

Tables had inlay and gilding as well as rich carving, and were sometimes topped with slabs of marble or Florentine mosaic.

A veneered library table made for one of the de Medicis of Florence is given particular mention by Pollen:

> It is veneered with ebony divided into compartments by columns of heliotrope, oriental jasper, and lapis lazuli, which have the bases and capitals of chased silver. The work is furthermore enriched with jewels, beautiful ornaments of silver, and exquisite little figures, interspersed with miniatures and terminal figures of silver and gold, in full relief, united in pairs. There are, besides, other compartments formed of jasper, agates, heliotropes, sardonyxes, carnelians, and other precious stones.[11]

Then too, the Italian Renaissance schools contributed wonderful skill in veneered work, carrying out the tones and effects of "panther tables," "tiger tables" and tables spotted as with "bees," as did their Roman predecessors 2,000 years before. In the Museums of Cluny, the Louvre of Paris and the great depositories of art in Rome, Venice and in fact throughout all Europe, are hundreds of the most priceless creations in the realm of furniture, many of them veneered.

However, not all of the furniture of this period is equally worthy of praise, and much of it is considered far more appropriate for display in museums than for use in modern homes.

Nevertheless, of the two centuries, it is granted, that the bud of artistic appreciation was opening into a flower of expression so universally admired that Italian artisans came to be much sought in Western Europe as masters to spread the spirit and form of Renaissance art.

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[11] Pollen, p. 75 (quoting Vasari).

## Marquetry in the French Renaissance

As intimated in the previous section, the industrial art of France in the 16th Century received a great impetus from the rebirth of art in Italy.

Francis I, the monarch of a most advanced and luxurious court, built and decorated his chateaux in the Italian style, and furnished them with coffers, chairs, cabinets, armoires, tables and other articles copied after the Italian models and veneered in a similar manner. The de Medici princesses and other wealthy subjects promptly adopted the same imitation of Florentine luxuries and refinements.

Cabinet-makers crossed the Alps to follow building activity from one French town to another. Native artists not only patterned after their works but were sent out expressly to learn the Italian manner of ornamentation and building. Further inspiration was brought back to France by military expeditions to Italy.

In the opinion of André Saglio:

> The costly expeditions to Italy had as happy results for the cultivation of French taste and the refinement of French manners as had the Crusades in a more barbarous age.[12]

With this new and stimulating interest in classical arts developing, at a time when the old principles had begun to pall with the abatement of religious fervor, it was not long before Gothic traditions were abandoned.

The tendency toward soaring height was retained, however, in some examples of architecture, and it continued as a quality of furniture in the French Renaissance. Cabinets rose to two, three or four stories and the elongated or pediment top was a distinguishing mark.

Carving was in a state of high development and perfection, and collections of this period show a decided fondness for util-

[12] "French Furniture," by André Saglio. Published by Charles Scribner's Sons, New York, 1907, p. 60.

izing the classical motifs. Walnut was the wood most used, as it easily lent itself to intricacies of pattern.

To those interested in veneers and in plywood, the most important method used by cabinet-makers was the inlaying of exotic woods, also ebony, ivory and metal. Many chests were elaborately inlaid. One of the three prize specimens of historic Hardwick Hall is a French-made, walnut cabinet, with outside panels finely inlaid with landscapes and floral ornament.

In connection with the marquetry of the period, Litchfield has this to say:

> Large armoires, chests of drawers and knee-hole writing tables were covered with an inlay of vases of flowers and birds of a brownish wood, with enrichments of bone and ivory, inserted in a black ground of stained wood, very much like the Dutch inlaid furniture of some years later, but with less color in the various veneers than is found in the Dutch work.[13]

## The Use of Inlay in the English Renaissance

In its lingering inheritance of English Gothic traditions, furniture of the Renaissance period in England, differs from the Italian and from the French.

Regarding the use of inlay as a form of veneering, the following is extracted from Roe's "History of Oak Furniture":

> The art of inlaying with different colored woods became fashionable during the 16th Century. This form of embellishment emanated from Italy, and, spreading through France and Germany, speedily became very much in favor. . . . During the latter half of the 16th Century, conventional floral decoration was much in vogue with the inlayers, but the simulation of quartered panels and geometrical insertions was also carried out.[14]

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[13] Litchfield, p. 62.

[14] "A History of Oak Furniture," by Fred Roe. Published by The Connoisseur, London, 1920, p. 10.

During the reign of Henry VIII, England began to be more free from the uncertainties of strife, and fortifications came to be no longer necessary. With the hiatus in the building of monasteries at the same time, the country was free to devote its resources and efforts to domestic architecture.

A further reason for associating the name of Henry VIII with the earliest beginnings of the Renaissance, was the violent anti-papist sentiment which led the King to import Italians for court architects, in his aversion to the Gothic style, which he associated strictly with matters ecclesiastical. Later, during the Reformation, German and Flemish artists displaced the Italian.

ELIZABETHAN. Even with this encouragement, the movement of the Renaissance did not come into full flower until the Elizabethan age, when life was gay, full of color and glory. Love of brilliant pageantry was apparent in the entertainment of the day. It was at this time that Shakespere's plays were written and produced for the amusement and edification of the court and the common people. Literature and art in all forms flourished.

Elizabeth's every whim became the preference of the land, and as her taste ran to splendor in court ceremony, dress and surroundings, so her subjects came to value ostentation and display in manners and possessions. Furniture, as ever, reflective of the spirit of the times, was showy rather than comfortable. Oak was the material used, in elaborately carved designs and massive forms.

Inlaid work continued in use for furniture, and this type of veneer also began to be adopted for wall-panelling. Blake and Reveirs-Hopkins define this characteristic of Elizabethan wood work as "the laying in of small pieces of one or several kinds of wood in places cut out of the surface of another kind."

The South Kensington Museum shows a representative specimen of inlaid panelling of the best period of the English

Renaissance, taken from Sizergh Castle, Westmoreland. This is described by Litchfield as follows:

> The paneling is of richly figured oak, entirely devoid of polish, and is inlaid with black bog oak and holly, in geometrical designs, being divided at intervals by tall pilasters with flutings of bog oak and having Ionic capitals.[15]

On the more extensive use of inlays, Burgess has this paragraph:

> The broad mouldings gave opportunities of ornamental inlays and the small panels on furniture, walls and chests were suited to the purposes of the inlayer. By means of different woods, inlays produced light and shade, and enriched the beauty of the so-called jewel work. What is technically known as strap and jewel moulding was much favored, also geometrical patterns; conventional flowers also made their appearance about that time.[16]

Hunter adds the following:

> Besides carving, inlay was frequently called upon to help make furniture beautiful; . . . pieces of olive and other light colored woods, set into channels excavated in the solid oak.[17]

Bed heads and testers, tables, chest fronts and cabinets were inlaid. Roe writes of a cabinet, the base wood of which is pine, now in the Victoria and Albert Museum in a fine state of preservation. This condition, we may reasonably assume, is due to its plywood construction.

> It is adorned with a number of boxwood carvings in high relief, representing battle scenes, while the flat surfaces are profusely overlaid with designs in marquetry of sycamore, pearwood, Hungarian ash, maple and other woods. On the base and bordering the inlay appear the rose and portcullis, emblems of the Tudor sovereigns of England.[18]

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[15] Litchfield, p. 81.
[16] Burgess, p. 79.
[17] Hunter, p. 317.
[18] Roe, p. 14.

Many examples of Elizabethan oak carvings are treasured in London as well as in the museums of this country. The grotesque figures and bold, exuberant forms seem to be less admired now as such than for their excellence and skill of workmanship.

Chairs were uncommon in the first half of the 16th Century except as "the chair of state," and "the several chairs of order." The custom had been general that persons of the household other than the master and mistress should use crude settles, stools and benches.

Under the reign of Elizabeth, and in the second half of the century, when trade with foreign countries developed a wealthy middle class, great progress was made in the advancement of domestic arts.

### Marquetry of the Dutch and Flemish Renaissance

Early in the 16th Century, through the liberality of Margaret of Austria, as "Governor of the Low Lands," Italian artistry was introduced into Holland and Flanders and native craftsmen were encouraged to adopt the new forms.

At first, oak was almost the only wood used in furniture. Ebony and other rare and colored woods, known to these seafaring folk through commerce with the Orient and the Indies, later came into prominence for decorative veneers on furniture and woodwork.

Wood-carvers were in popular demand for the beautifying of palaces, churches, public buildings, and the homes of burgomasters and other wealthy citizens.

In many paintings of Dutch interiors, marquetry decorations on furniture are also evident. Certain authorities consider it too luxuriant in detail, and Litchfield grants the point as applicable to the later years:

> Marquetry of this period is extremely rich and the designs are less severe, but the coloring of the woods is varied

> and the effect is heightened by the addition of small pieces of mother-of-pearl and ivory. Later, this marquetry became florid, badly finished and coloring of veneers crude and gaudy. Old pieces of plain mahogany furniture were decorated with a thin layer of highly colored veneering.[19]

While less graceful than the Renaissance styles of other countries, still there is a domestic and solid character to the furniture, that is likable. There is a charm also in perceiving that the national love of flowers has left its stamp in the tulip and other popular floral designs.

An excerpt from Jackson's book on the art is illuminating in studying Dutch marquetry:

> In the lower Rhine and in Holland, tarsia was used for great and small chests, sideboards and doors with rich gable crownings, with good drawing of flowers and sprigs of leaves with birds and beasts among them, the ground being generally light. . . . The best period in Holland was the second half of the 16th and the first half of the 17th Century. In the work of this period the handling is broad, and the composition often a little over-full, but the many different woods which Dutch commerce made available seduced the marqueteurs into too pictorial a treatment in point of color. . . . Here, as well as in France and Italy, rich chairs were commonly decorated with marquetry.[20]

## Inlaying as a Feature of the Spanish Renaissance

The change from Gothic style to Renaissance which has been noticed in other countries is apparent in the furniture and wood work of Spain. The spirit of the revival in Italy was a strong influence, since the countries were both under the imperial patronage of Charles V.

The Eastern art of inlaying was a conspicuous feature of this Spanish style. The testimony of Jackson is interesting in connection with this form of veneering:

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[19] Litchfield, p. 66.
[20] Jackson, pp. 91, 92.

> In Spain there must have been a good deal of intarsia done, seeing how long the Moors held the Southern part of the country, but very little has come down to us. . . . In the Museum at South Kensington are some panels with Hispano-Moresque geometric inlays of bone of the 15th Century, which are very pleasing; the ground is of chestnut, the bone is often stained green, and metal triangles and light wood are also used. This use of bone, which is frequently tinted, in conjunction with black and pale wood, is characteristic of Spanish work of the 16th Century. The design is often exceedingly naive, employing birds, animals, plants, and trees with scrolls and monsters. There is one cabinet at South Kensington with the animals entering the ark, which is most entertaining.[21]

Litchfield gives the following, as an example of inlay applied to interior woodwork and panelling:

> In the Chapel of St. Bruno, attached to the Carthusian Convent at Granada, the doors and interior fittings are excellent examples of inlaid Spanish wood of the 17th Century; the monks of this order at a somewhat earlier date are said to have produced the "tarsia," or inlaid work.[22]

The lamentable dearth of comfortable domestic furniture in Spain may be attributed to the Moors, among whom convenience was not a quality to be considered. They left individual marks traceable from their earliest occupation up to the present day—a semi-oriental note.

Up to the beginning of the Renaissance, furniture in Spain is said to have consisted principally of chests, of a range in size and workmanship sufficient to meet every conceivable need. They were of Gothic carving, or of plywood construction—inlaid on both sides of the lid. The "coffer of the Cid," once loaded with sand and foisted upon the usurers as filled with specie, as the early story goes, is reputed to be the one still shown at Burgos.

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[21] Jackson, pp. 81, 82.
[22] Litchfield, p. 70.

During the 16th and 17th Centuries, love of luxury impelled the creation of diversified forms, and ornate and magnificent furnishings came to be the standard. The showy vargueño was a favorite article. Of the decorative veeners on these fascinating cabinets, Litchfield says:

> The vast wealth and resources of Spain at this period of her history enabled her nobles to indulge their taste in cabinets, richly ornamented with repoussé plaques of silver and later of tortoise-shell, of ebony, and of scarce woods from her Indian possessions. [23]

Tables, as well as cabinets, were inlaid and veneered with ivory, ebony, bronze and silver. The use of beds and brasiers was derived from Ancient Rome. To the Moors is imputed the custom, prevailing until two centuries ago, of seating the Christian women upon cushions, and the men, according to their rank, upon chairs or stools.

Leonard Williams devotes several pages of "The Arts and Crafts of Older Spain," to the legislation by city ordinance in Granada in the early 17th Century, against the making of defective furniture. This practice had been indulged in to such an extent that it had grown to be a scandal in that town.[24] Superior craftsmanship has never been a salient quality of Spanish furniture.

Native chestnut, because of its richly lustrous quality, was much in favor. Walnut, oak, cedar, cypress and pine were woods also used for furniture. Metal mounts were much in evidence, and entire pieces of wrought iron were popular in curved designs.

Ponderous stools and armchairs, with studding of huge brass nails and coverings of richly colored velvets or elaborately stamped leathers, were characteristic. Gilding, painting and

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[23] Litchfield, p. 67.

[24] "The Arts and Crafts of Older Spain," by Leonard Williams. Published by T. N. Foulis, London, 1907, Vol. II.

gold embroidery were lavishly applied. Indeed, every possible embellishment was employed that could be devised to administer to the pride of the Spaniard in this his period of greatest grandeur and power in all history.

# CHAPTER IV

## POPULARITY OF MARQUETRY AND OTHER FORMS OF VENEERING IN LATER FRENCH FURNITURE

The period of Louis XIII is interesting in the study of furniture types because it marks the fruition of a desire that furniture should possess something more than strength. New uses were developed for domestic furniture. About this period, cabinets with hinged doors instead of drop-fronts, became the vogue, on many of which marquetry, in patterns of flowers and baskets of fruit, inlaid in surfaces of fine veneers on the panelled doors, was employed as ornamentation. The popular taste ran to gilded furniture embellished with real mosaics.

On the whole, however, the Baroque, or symmetrical Louis XIII style, does not appear to have exerted a very definite influence on modern style tendencies.

### Louis XIV (1643–1715)

The seventy-two years' reign of Louis XIV is unequalled in splendor, and is a never-to-be-forgotten time in the artistic and political annals of France. At this time, a supremacy in matters of style and taste was acquired which has not been relinquished even to this day.

To the story of veneers and of plywood, the period contributes the innovation of Boule work, a kind of veneer still outstanding in rich and novel furniture decoration.

André Charles Boule, for whom the work is named, was originally a worker in ebony, who gradually enriched his patterns with inlays and "clever coverings," until the art was raised to the highest possible degree. (See Illustration 12.) He was given the distinction of Head of the Royal Furniture

Department and was lodged in the Palace of the Louvre. His outstanding achievement in veneering was a method which imposed thin brass upon tortoise-shell, with the occasional addition of ivory and enamelled metal. In his earlier work, Boule could produce this type of inlay only at prodigious cost, because of the waste of much valuable material in cutting. Subsequently, the process was worked out more economically. In this later work, known as "new Boule," the tortoise-shell is laid over a gilt or vermilion ground, effecting a very subtle blending of color. In Boule work, all parts of the marquetry are held down by means of glue, to the bed, which is generally of oak.

It is generally conceded that the French period of art dates from 1667 when Colbert, Minister of Finance to Louis XIV, founded the Academy of Painters and Sculptors, to which students of architecture, wood work, ornament and furniture were admitted. At his behest, the factory of the Gobelins, still famous for making pictorial tapestry, was purchased by the government. Under royal patronage, and with Le Brun, the Chief Court Painter, as Director of the tapestry works, artists from all countries were gathered to work for the glory of France, and there was developed a truly regal and magnificent style which became the universal fashion. Its resemblance to Renaissance is attributed to Cardinal Mazarin, who drew many artisans from Italy, his own country.

The Louis XIV was a classic style in furniture, easily distinguished by its straight lines somewhat relieved by a few large curves. The conventionalized acanthus and anthemion were conspicuous figure in its designs. Ornament was lavishly, though not excessively applied, and the general effect produced was balanced and symmetrical. The painting, gilding, inlay, lacquer, and metal mounts were typical embellishments which differentiated the period from the preceding one, when carving had been the principal method of decoration. For the most part, colors were sombre and dark.

Cabinets and commodes, long salon tables and high-backed chairs, all bespeaking dignity and masculine strength, came into fashion. Chairs were upholstered in gorgeous brocades, damasks and velvets. The rich and ornate effects in chateaux were heightened by bronze and marble mantels, huge pier-glasses and canopy beds.

Oak, walnut, ebony and chestnut were all used at this time in making furniture, although some writers characterize the age as "the triumph of gilded wood." Rare woods of different kinds were used for inlays, as was also the veneer of metal inlay over tortoise-shell, already described as Boule work.

The Palace of Versailles, built in a beautifully parked tract just outside Paris, perpetuates the personality of Louis XIV. The vast gardens and extensive interior offered unlimited scope to the artists and designers of his kingdom. The enormous "Hall of Mirrors," memorable in the World War for the signing of the Treaty of Versailles, is only one of a succession of rooms, impressive for their elegance and formal magnificence. It is interesting to know that the table at which the document was signed was plywood built. One cannot pass through the stately halls without reconstructing the scenes of grandeur and martial pomp, which marked entertainment under the "Grand Monarque" or "Sun King."

The enormous bedchamber of Louis XIV was for many decades the center of government and society of France. It was elaborately decorated and furnished in handsome pieces, trimmed with Boule marquetry.

## Louis XV (1715-1774)

The first eight years of this reign, known as the Regency period under Philip of Orleans, concern our history of veneers and of plywood chiefly because of the decorative work of Charles Cressent. Many pieces of this talented cabinet-maker and sculptor are adorned with the tortoise-shell marquetry

learned from Boule; others are in marquetry of many colored woods.

Outstanding in the period of Louis XV and Louis XVI, as fine cabinet-makers and artists in marquetry, are the names of Riesener and David Roentgen. They were known as ébénistes or workers in ebony and other exotic woods, after the time when ebony was brought into Europe from the Dutch settlement in Ceylon.

To quote Pollen:

> Riesener used tulip, rosewood, holly, maple, laburnum, purple wood, etc. Wreaths and bunches of flowers, exquisitely worked and boldly designed form centers of his marquetry panels which are often plain surfaces of one wood. On the sides, in borders and compartments, we find diaper patterns in three or four quiet colors. These conventional sides or corners of diaper work help to give point to the graceful compositions that form the principal feature in his marquetry. Chests of drawers and cabinets are sometimes met with in snake wood and other varieties of brown wood, of which the grain is waved or curled without marquetry. . . . The most imposing of the Wallace Collection, which now has many of Riesener's best pieces, is the rounded bureau or secrétaire, made for Stanislaus, King of Poland. It is beautifully inlaid on the top, ends and back with designs emblematic of the sciences and with bust heads. . . . .
>
> David Roentgen worked as a contemporary of Riesener, but was younger. He made marquetry in lighter woods and of rather a gayer tone than Riesener. . . . In his light marquetry, David used various white woods. Pear, lime, and light colored woods were occasionally tinted with various shades by burning. This process, originally effected by hot irons, is better and more delicately managed by hot sand. Only browns and dark ochrous yellows are obtained by this means, and the more delicately toned marquetry is without hues of green or blue. . . .
>
> Contemporaneous with Riesener in France was the Italian maker of marquetry, Maggiolino.[1]

[1] Pollen, pp. 109–110.

Under the regent, the great-grandson of Louis XIV grew up to be wasteful, extravagant and profligate, and the character of Louis XV furniture is distinguished by audacity and caprice. Clifford draws a comparison between the two reigns in this wise:

> The arts of Louis XV were stimulated by social life, elaborate ostentation and extravagance, in contrast to the arts of Louis XIV, stimulated by the world force of conquests and statecraft.[2]

The styles of this period were dictated by Comtesse du Barry, Madame de Pompadour and a succession of mistresses whose tastes were gay and elegant to a degree. Watteau's designs were popular in dainty landscape scenes, expressive of the spirit of the times.

In pitiful contrast with the rank extravagance of court life was the wretchedness of the common people, whose sufferings culminated in the bloody revolution, which put an abrupt end to the reign of Louis XVI.

Following the establishment of extensive trade relations with China, Chinese styles were adopted, in so far as they could be fitted to European environment. Lacquer became popular, particularly the Vernis-Martin species, developed in France by a secret process in imitation of the oriental.

Rococo is the German term used to characterize Louis XV style. It was a back-to-nature reaction, featuring the rock and shell motif (from which the term is taken) as well as wreaths, flowers and human figures. Structural lines are all curved, and under Messonier, as Royal Designer, all pretense of a balanced pattern was abandoned. Grace and beauty of detail were worshipped. Plain surfaces were abhorred.

The dark and heavy marquetry of tortoise-shell and metal, made famous in the preceding reign, was displaced by a mar-

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[2] "Period Furnishings," by C. R. Clifford. Published by Clifford & Lawton, New York, 1911, p. 137.

quetry of thin veneers of exotic woods, imported for the purpose. Good workmanship was an essential.

Characteristic pieces of the period were chaise-longues, commodes, cabinets, dressing-tables, desks and beds, with towering canopies.

Litchfield says of Louis Quinze cabinets:

> They were inlaid, not only with natural woods, but with veneers stained in different tints; and landscapes, interiors, baskets of flowers, birds, trophies, emblems of all kinds and quaint fanciful conceits were pressed into the surface of marquetry decorations.[3]

A beautiful commode of plywood construction, bequeathed to the Victoria and Albert Museum in London by Mrs. Julia Bonnar, is described as of oak, veneered with tulipwood, ornamented with marquetry of harewood, sycamore and other woods and with mounts of ormolu. An exquisite inlay of a basket of flowers adorns the center of the front.

All the characteristics of the period are brought to a climax in the most remarkable piece of the 18th Century, "the Bureau du Roi," reproduced in Illustration 13.

This superb classic is still preserved intact, in the Palace of the Louvre, at Paris. It is the last word in the art of veneering—demonstrating that the best effects are brought into relief against the softening backgrounds of fine veneers.

In 1760, "The Bureau du Roi" was begun for Louis XV by Oëben, a pupil of Boule, and it was finished and signed by Jean Henri Riesener in 1769. It is a cylinder desk, five and one-half feet long and three feet deep, the prototype of the "roll-tops" of our later days. Its decorations are done in magnificent marquetry of "flowers and trophies of poetry and of war." The bronze figures representing Apollo and Calliope were designed by Duplessi. One figure holds a branch bearing a clock on which figures of little children are dancing.

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[3] Litchfield, p. 155.

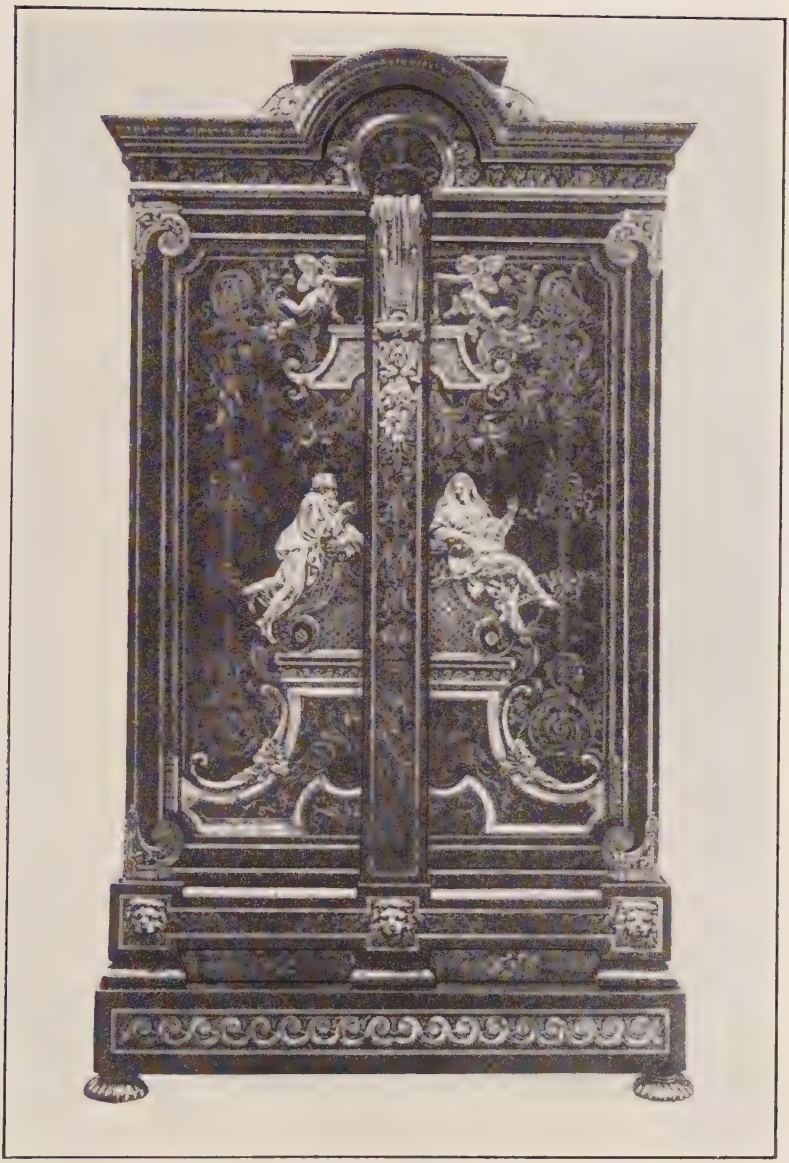

Illustration 12. Louis XIV Armoire by Boule, with copper and mother-of-pearl inlay on ebony.

Courtesy, Dean-Hicks Co., publishers of "Decorative Furniture," by George Leland Hunter.

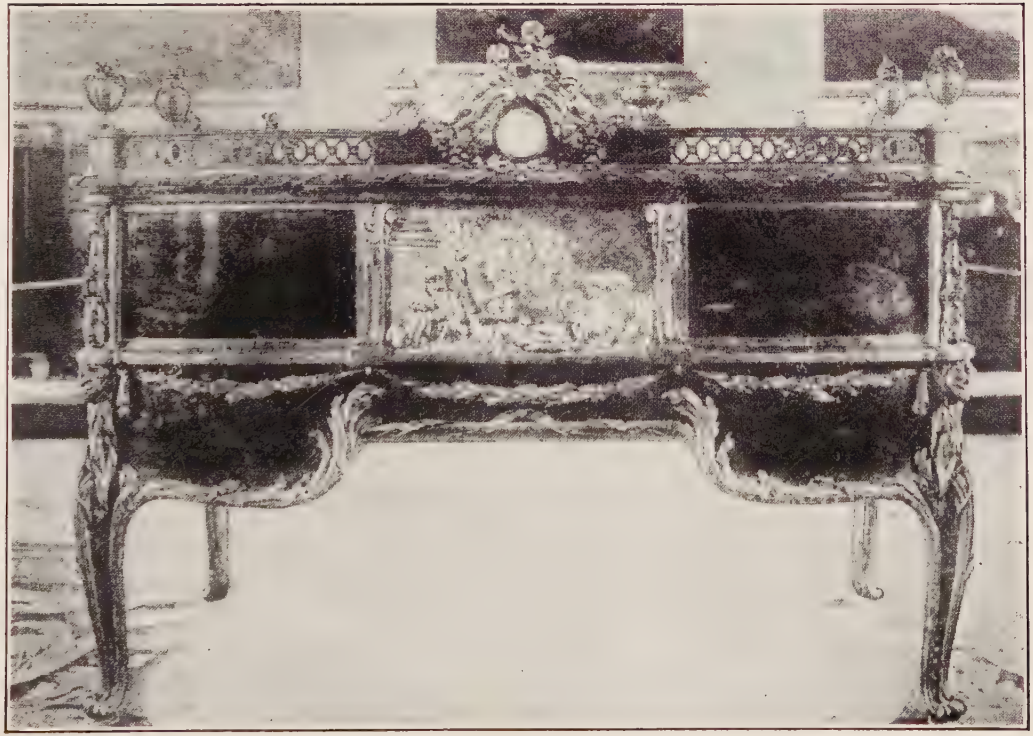

Illustration 13. "Bureau du Roi," considered the finest piece of furniture in existence and the last word in the art of veneering. Now in the Louvre, Paris.

The editor of *The Guardian* in London includes these points in his well-known description of "The Bureau du Roi":

> It is remarkable alike for the boldness of its conception and the magnificent finish of its details—its lines are large, flowing, harmonious. It is the most famous and magnificent piece of furniture ever constructed.

This most famous of all exhibits of plywood in furniture cost the King a million francs and required nine years in the making. It is beautifully veneered with the rarest of fine woods in sumptuous designs and has perhaps the most delicate and perfect inlays in the world.

The construction is of plywood throughout—in principle and in fact.

## Louis XVI (1774-1792)

Long before the accession of the youthful Louis XVI, the frivolities and excesses of the Louis XV style had grown so wearisome that the pendulum was swinging back to straight, classic lines. This trend towards the antique in design was strengthened by the attention given the discoveries of Herculaneum and Pompeii, buried for generations under the ashes of Vesuvius.

The style in furniture seemed to follow Marie Antoinette's simple but exquisite taste in dress and to be the reflection of the Queen's own gentle personality. Clifford discerns, also, "a well-defined effort to purify decoration which had run the limits of extravagance."

Seymour de Ricci has published a volume on Louis XVI furniture almost entirely devoted to plate reproductions.[4] Many of the illustrations, culled in his painstaking study from famous monographs and fine catalogues, reveal plywood construction and unique and highly decorative uses of veneers.

[4] "Louis XVI Furniture," by Seymour de Ricci. Published by G. P. Putnam's Sons, New York.

Several "bureaux à cylindre" depend for their principal adornment upon beautifully grained veneers; other roll-top desks are more ornate with the exquisite marquetry of Riesener and David Roentgen. A mahogany "bureau with its secrétaire à archives" has drawer fronts and a door of plywood. Three or four higher desks, "secrétaires à abattant," show wide drop-fronts and cupboard doors, plywood built, covered with beautiful veneers matched to form striking patterns. The semi-circular commodes pictured could only have been constructed by the employment of the veneer and plywood principle, and the finely selected, long grain face veneers show full appreciation, in this age of restraint, of the refined effects which may be produced in wood.

In general effect, the furniture of the period was dainty, graceful and elegant. Ornament included carving, painting, lacquer and ormolu mounts, in addition to the elaborate marquetry and the veneer. Toward the close of the period, slender ovals or Sèvres placques were characteristic. Delicate fabrics were used for upholstery, in soft, pastel shades.

Mahogany, walnut, oak and satinwood were used, and rosewood, tulip, amboyna, kingwood, ebony, pear, holly and every other precious wood having decorative possibilities for the cabinet-makers seem to have been ingeniously employed.

The Louis XVI style exerted a definite influence upon Sheraton design in England, and the motifs reappear in American furniture in the Duncan Phyfe models.

In the South Kensington Museum, London, may be seen yet another classic of the too little appreciated fine arts of veneer and of plywood, namely, the beautiful writing desk, or "escritoire à toilette," dated 1780, once the personal property of Marie Antoinette. It is veneered with tulipwood, inlaid with marquetry of kingwood and box, with ivory trim. (See Illustration 14.)

Another rescued treasure, which is also deeply interesting, is a superb sideboard and knife-cabinet, veneered in mahogany

Illustration 14. "Escritoire à Toilette," dated 1780, once the personal property of Marie Antoinette, veneered with tulipwood, inlaid with marquetry of kingwood and box, with ivory trim. Now in South Kensington Museum, London.

Illustration 15. Sideboard and Knife-Cabinet, once the property of Marie Antoinette, veneered in mahogany throughout, with ebony and satinwood banding.

throughout, with ebony and satinwood banding. This too, was the property of Marie Antoinette. The base of this plywood construction is oak. (See Illustration 15.)

This rare example of the art of the plywood craftsman is said to have been saved from the wreck of the French Revolution by an American, General Knox, and at the suggestion of Prince Talleyrand, brought to this country, where it is still shown as the "pièce de resistance" of the Historical Museum of Portland, Maine.

After nearly two centuries of adventure, this classic still stands supremely beautiful and perfect in its mutely eloquent confirmation of the enduring qualities of plywood and veneer.

## Empire

The radical changes in furniture of the Napoleonic era are explained by Pollen as follows:

> The French Revolution put a complete stop to the old arts of domestic life in France. As in the 16th Century, so in the 18th, the new ideas rush extravagantly in the direction of republican antiquity and Roman taste and sentiment. It was under the Empire, after the Italian wars and Egyptian expedition, that the means and taste for expenditure upon civil furnishings and decorations revived, with an assumption of classicalism. . . . We see chairs and tables imitating bas-reliefs and the drawings on antique vases.[5]

The Empire style is an expression of the great ambition and vanity of Napoleon. His campaigns diverted public attention from artists and their works; thus he was able to control talent and dictate design. Antiquities interested him, particularly those of Rome, because of their association with military power and glory, and he commissioned artists and artisans to imitate the old lines in furniture. As a result of his victorious expedition to that land of unique civilization, Empire style also

[5] Pollen, pp. 113–114.

embraces the designs of ancient Egypt. Of all French styles, the Empire is considered by Hunter and other writers to be the least French.

Not all authorities unreservedly admire Empire furniture, but Dyer views it in this light:

> The furniture of the period expressed not a court, not an epoch of French life; it expressed the overwhelming personality of Napoleon Bonaparte. It was a period of heroics, of ceremony, of novelty. Napoleon aped the grandeur of the Caesars, and the design details of the period were suggested by the idea of imperialism and conquest.
>
> The decorative styles, which were based largely on the imperial Roman, became cold, formal, heavy, with little of the light or fanciful about them. They were not lavishly magnificent, like the styles of Louis XIV, yet, though somewhat stiff and constrained, they were not without a certain dignity and grandeur and were never effetely luxurious.
>
> Empire furniture was characterized by good cabinet-work, finely executed metal mounts, beautiful mahogany, and rich upholstery. Construction was for the most part simple, but it was a heavy, formal simplicity, not the graceful simplicity of Louis XVI.[6]

The finest mahogany crotch was the chief veneer employed by Empire cabinet-makers for veneering the panels of doors and drawer fronts, to produce a rich and varied effect.

The style developed was ponderous and ostentatious. An enormous scroll was always in evidence. Upholstery was bold in color and pattern.

In carvings and mountings, Empire furniture was esteemed as technically perfect, though not always coherent. The letter "N" in a victor's wreath is often the central figure, and Clifford adds these details:

> Decorative motifs were classic appliqués on massive frames; the wreath and laurel branch, the torch, Napoleon bee and crown became conspicuous; winged figures were pop-

[6] Dyer, p. 80.

Illustration 16. Napoleon's "Bureau de Campagne," plywood throughout, faced with rosewood veneer, banded with copper inlay and bound with copper edges.

ular as emblematic of liberty; heads of helmeted warriors, trophies of lances, surmounted by the Phrygian cap were significant details.

After the Italian and Egyptian wars, the French boldly adopted all that was significant of conquest.[7]

A conspicuous example of the use of plywood in furniture during this particular period, is still to be seen in a desk and chair set, once the personal property of Napoleon Bonaparte, shown in Illustration 16. Accompanying "The Little Corporal" from one end of Europe to the other—on the march, at the gallop, in action constantly on the most famous battlefields of history—this cabinet, plywood built, stands today in almost perfect condition, in spite of many years of merciless treatment.

Designed for Napoleon by Sacci of Florence, it was built to his own specifications. It is plywood throughout—faced with rosewood veneer, banded with copper inlay and bound with copper edges. The tops are thin flats of polished green marble. The central part of the desk, with shelves and drawers, rises automatically and brings out the three-legged chair which is covered with red morocco. The desk and chair are intercollapsible. Both are veneered.

Twenty years of military service, the most terrific on record and not a chip in them! What wonder that the grenadiers of the Old Guard called this wonderful and magnificent example of the endurance test of plywood and veneer, Napoleon's "Bureau de Campagne"!

[7] Clifford, p. 163.

# CHAPTER V

## VENEERING IN THE JACOBEAN PERIOD (1603–1689)

The Jacobean or Stuart was a development of the Tudor style, which began in the time of Henry VIII, when early Renaissance mingled with the Gothic, and continued through the reign of Elizabeth. Early in this period, massiveness, then synonymous with utility, predominated in the furnishings of the home. We have Mallett as authority for the statement that in Tudor and Stuart days "almost everything was made of solid wood, and though the decoration varied, the whole of this solid work was dependent rather on form than color for its effect." [1] Later, however, with the restoration of the monarchy, furniture, in which beauty and color were also considered factors, began making its appearance, and, as a natural corollary, it follows that the use of veneering became more general.

Authorities differ as to extent of the Jacobean period and this uncertainty is recognized by the oft-quoted Pollen when he says:

> The various reigns sometimes supply more convenient dates than the beginnings or end of a century, for marking changes in national tastes, in such matters as furniture. The names of kings or queens are justly given to denote styles, whether of architecture, dress or personal ornaments, or utensils of the household.[2]

This period takes its name from James I, but it is principally to the liberality of the dashing Charles I that the earliest

[1] "An Introduction to Old English Furniture," by W. E. Mallett. Published by Charles Scribner's Sons, New York, p. 14.

[2] Pollen, p. 85.

division of the period really owes its individuality. He it was who encouraged the architect, Inigo Jones, whose influence was responsible for introducing into England the pure classic forms of the later Italian Renaissance. Had Charles' reign been less disturbed by civil strife, no doubt domestic arts would have made rapid progress, as he was extremely receptive to foreign influences.

The furniture produced by cabinet-makers of this time differed from that of Elizabethan days, in that it was more formal in effect and less extravagant in ornamental detail.

Though fine carving was the characteristic decoration, inlay was still employed to some extent. Percy Macquoid, in his four volume "History of English Furniture," pictures one of a pair of cabinets of plywood construction which belonged to Queen Henrietta Maria, wife of Charles I.

He says:

> The facing is of laburnum wood, cut from long transverse sections of the tree, the lighter portion of the wood next the bark being retained as an ornament, instead of being trimmed away, as is usual in this sectional veneer. The drawers are bordered with finely run mouldings of walnut, and the door has center panel mouldings in the same character. . . . The stand has outer mouldings and flat stretcher alternately inlaid with the light and dark colored parts of the wood.[3]

Museums have specimens of wall-panelling, balustrades, mantel-pieces and furniture. It was still the "Age of Oak," to adopt Macquoid's classification. Massive cupboards, chests and bedsteads, with a sturdy British look about them, are typical.

"The true Jacobean style reached the height of its development during the reign of Charles I," declares Dyer.

Furniture of the latter half of the 17th Century began to take on the curves and ornamentation affected by the French, due in part to the influence of Sir Christopher Wren, the archi-

[3] "A History of English Furniture," by Percy Macquoid. Published by G. P. Putnam's Sons, New York, 1905, Vol. II, p. 19.

tect who was dominant in England after Inigo Jones and who left as his monument St. Paul's Cathedral in London. The architecture and furnishings of Hampton Court Palace, outside London, show Wren's devotion and adherence to French art.

It is commonly granted that the civil wars of the period not only retarded the production and development of furniture but also hastened the decay of Renaissance art.

## The Commonwealth

The Commonwealth added little to the development of furniture. On the contrary, there was much wanton destruction of all that had been held dear by royalty. We read of the more general use of chairs, since, under the new etiquette of democracy, they were no longer reserved for the exclusive use of my lord and lady. It is remarked, also, that the addition of a drawer to the chest began in the days of Cromwell.

One example of furniture of the Cromwellian time, reproduced in Pollen's handbook on the Victoria and Albert collection of the South Kensington Museum in London, is interesting in the history of veneers and of plywood. However, the majority of the work was severe and plain and had little of artistic merit to recommend it. Pollen has written of this cabinet:

> It is of oak inlaid with chestnut, ebony, ivory, and mother-of-pearl, and shows in decoration, traces of oriental ideas, probably through the Dutch, who after the victorious issue of their heroic struggle with Spain were beginning to exercise great influence on the politics and art of England and other countries.[4]

Illustration 17 "is a fine example of favorite double chest form of cabinet," inlaid with marquetry "imported probably from Rhine Provinces."

[4] Pollen's Handbook, p. 98.

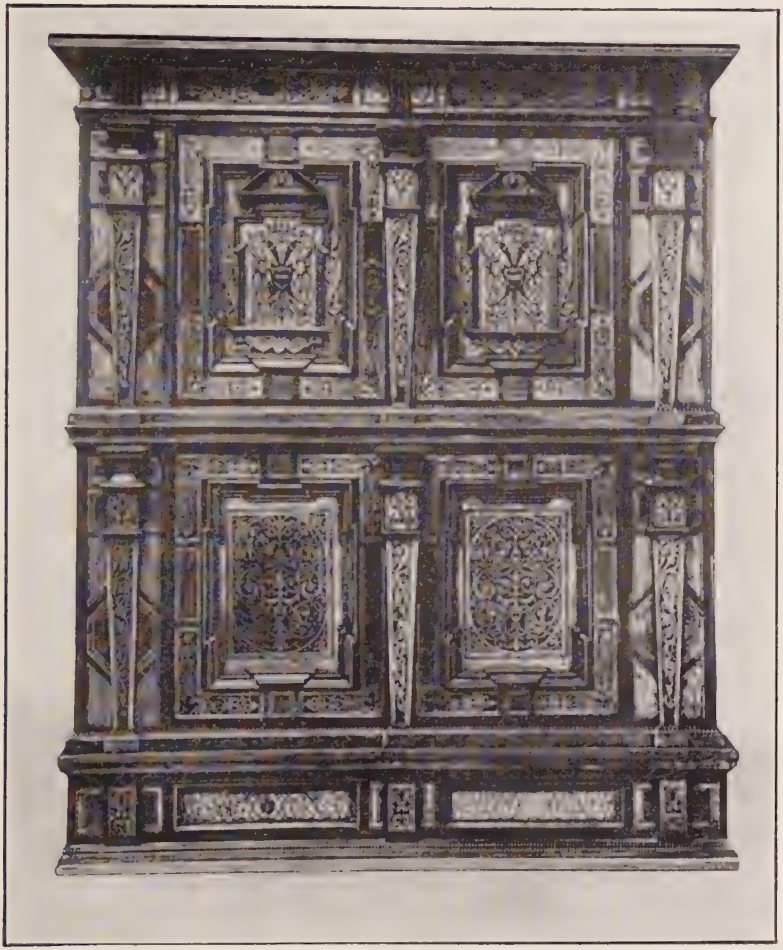

Illustration 17. Double Chest, inlaid with marquetry, probably imported to England from the Rhine Provinces, about 1656.

## The Restoration

The radical change in furniture fashions of the Carolean epoch, or the Restoration, is explained by Percy Macquoid as follows:

> In 1659 Cromwell died and with him the simple taste, that, owing to dearth of imagination, had gradually drifted into the commonplace. . . . Restoration of the Monarchy was accompanied by entirely new forms of thought, for not only were the tastes of the sovereign very strongly tinctured with those of France and Flanders, but the return of a large number of adherents who had shared his exile in these countries created a sudden change of fashion and manners, in strong contrast to the existing conditions of social England.[5]

Turning from the oak of accustomed usage to the more facile walnut, Macquoid's volume on "The Age of Walnut" is also the authority for this statement regarding plywood with walnut facing:

> The new style that commenced in England about the middle of the 17th Century was particularly suitable for the employment of walnut, as twists and curves, when on the cross grain, were less liable to chip in this wood than in the porous oak; and although the general construction and lining of cabinets and small furniture continued to be made of oak, the outer surfaces were veneered with walnut with applied mouldings worked in the same wood.[6]

According to Helen Churchill Candee:

> Two matters influenced greatly the furniture makers of the middle of the 17th Century. And these had less to do with kings and courts than with humble folk. One was the invention of a saw, the kind of a saw that would divide a plank into as many thin sheets of wood as were desired. Naturally, those who looked upon these thin sheets imagined new ways of using them for the embellishment of furniture.

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[5] Macquoid, Vol. II, p. 1.
[6] *Ibid.*, p. 6.

> Heavy carving had been almost the only ornament, when inch-thick planks were the usual material. Now, a wondrous field of possibilities lay before the ambitious in the way of inlay and veneer.
>
> . . . . The second matter which made a change in the general aspect of furniture in the second half of the 17th Century was the use of walnut wood in place of oak.
>
> . . . . Putting together the invention of the saw which could slice wood as thin as paper as well as fret it into seaweed, and the adoption of walnut wood, still another type of beauty in furniture was produced, that of the plain large-paneled scheme. By cunning skill, panels of walnut veneer were produced, where the grain of wood supplied the design.
>
> Add to this the wonderful finish of the cabinet-maker, and the piece had the beauty of bronze and the simplicity of classicism.[7]

So began the extensive cutting of the fine growth of English walnut trees, providentially planted at the end of Elizabeth's reign.

Macquoid pictures walnut tables, veneered and inlaid with marquetry, and chests of drawers of the same description, with veneered transverse sections of laburnum wood forming the oval bands surrounding the center. He pictures a table top of the whorled or "oyster shell" veneer introduced late in the Jacobean period.

Of this feature he says:

> The banding between the panels has become broader, in order to accommodate the so-called oyster shells of walnut of which the veneer is composed; these were taken from the boughs, sliced up into transverse sections and were for many years a favorite feature on English walnut furniture.[8]

Macquoid also describes tables of the latter part of the 17th Century, some with tops upheld at the corners by the admirably carved figures of the unrivalled Grinling Gibbons or one of his

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[7] "Jacobean Furniture," by Helen Churchill Candee. Published by Frederick A. Stokes Co., New York, 1916, pp. 27–29.

[8] Macquoid, Vol. II, p. 48.

pupils. And one highly finished table made of maple wood has a plain frame "veneered with the knotted portions of the maple." Another has a top "edged with a waved border not often found on English furniture."

Gate-leg tables were evolved, besides many gaming tables and other small stands to supplement the use of the long "refectory" tables.

Burgess presents a point in this paragraph:

> The moulded paneling, a distinct feature in the furniture of Charles II, is one of the characteristics of the closing years of the Stuart era. These panels, arranged in geometrical lines, took the place of the inlays of Elizabethan days.[9]

Another authority declares, on the other hand, that in the furniture of the Stuart period every variety of inlay or marquetry was extensively employed.

Macquoid confirms this assertion and devotes an entire chapter to marquetry, which begins:

> About 1675, small tables, clocks and certain other forms of furniture began to be ornamented by marqueterie, and this revived style of decoration is a very distinctive mark in the change of taste. It differed from early marqueterie in the process of construction, the pattern, together with the background, being now laid down as a veneer, and for this reason the shapes of inlaid furniture of this period are frequently sacrificed in order to obtain suitable flat surfaces. . . . At first the design of acanthus-leaved arabesques and birds, inlaid in brown and buff colored woods, was probably inspired by the Italian inlay of the time, whilst that representing flowers and birds in the altogether more realistic manner, produced rather later, was of Dutch inspiration. These two styles amalgamated towards the end of the reign of William; then by degrees the flowers were left out of the design, and the marquetry became an intricate series of very fine scrolls.[10]

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[9] Burgess, p. 92.
[10] Macquoid, Vol. II, p. 40.

Lest it be thought that the furniture of the extravagant age of Charles II was gaudy and too ornate for good taste, Macquoid reminds us of the brilliant settings which "demanded vivacity in the accompanying furniture." He states:

> The revival of color was the first protest against the greys, browns and drabs of the previous decade, and represents the early Carolean feeling of fashionable decoration, which was presided over by Castlemaine and Nell Gwyn.[11]

The great luxury in the latter part of the reign of Charles II is evidenced by the use of silver furniture in elaborate patterns, a fashion borrowed from the French court.

[11] Macquoid, Vol. II, p. 12.

# CHAPTER VI

## GENERAL USE OF WALNUT VENEERING IN THE ANGLO-DUTCH OR QUEEN ANNE PERIOD (1689–1720)

The rulers of England seem to have exerted a less conscious and deliberate influence on the fine arts of their country than did the kings of France, whose patronage has given name to many of the most distinct periods and individual styles. The term, Queen Anne, however, is broadly used to denote the styles prevailing during the reigns of William and Mary, Queen Anne and part of the reign of George I.

To the entrance of foreign factors, which calmed the court to a quiet sedateness, may be traced the marked changes in furniture during these reigns. The foreign elements introduced were gradually so well assimilated that the style with which we associate the name, Queen Anne, now shows but faint traces of the Dutch, the French of Louis XIV and the oriental influences, which had been paramount.

The Anglo-Dutch epoch embraces the time designated by Mallett as "The First Period of English Veneer." Blake and Reveirs-Hopkins declare that in the period under review, the practice of walnut-veneering is deserving of special mention, as at this time it reached a state of great perfection, "beautiful effects being produced by cross-banding[1] various strips and varying the course of the grains and the shades." In "Queen Anne," of the series of "Little Books about Old Furniture," these joint authors go on to say of the plywood process:

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[1] The use of the terms, "cross-banding," "veneered transverse sections," and similar terms in Part I, refers entirely to decorative effects in face veneer rather than to the interposed layer, between face and core, that is described in Parts II and III, and that serves to counterbalance internal strains and prevent warping and twisting.

The object of veneering was not for purposes of deception, as it was not intended to produce the effect that the whole substance was of the choicer sort of wood; but by means of applying these thin overlays a greater choice of wood was possible, and a more beautiful effect was produced by the juxtaposition of the various grains.

Although at the present time the term veneer is frequently used as one of opprobrium, the principle it stands for is a perfectly honest one. It is very much the same as the application of the thin strips of marble to the pillars and walls of St. Mark's at Venice, which is called incrustation and of which Ruskin writes in the "Stones of Venice." The basis of St. Mark's is brick, which is covered by an incrustation or veneer of costly and beautiful marble, by which rich and varied color effects are produced, which would have been impossible in solid marble.

The same principle applies to veneers of wood, in which there is likewise no intention to deceive but rather a desire to make the most of the materials on hand. It would have been impossible to construct a great many cabinets of solid walnut wood, nor would the effect have been so satisfactory, because, as already pointed out, the fact of veneers being laid in thin strips immensely increases the choice of woods and facilitates the composition of pleasing effects. There is, moreover, often a greater nicety of workmanship in the making of veneered furniture than in the solid article.[2]

As in furniture, so in contemporary wood panelling, did walnut serve—often cross-banded, veneered and inlaid with other woods of fine texture.

William, as Consort at the beginning of the Queen Anne period, brought from the Netherlands his love for domestic comfort, his sober taste for orderly neatness and his preference for the pleasures of country living, as opposed to the intrigues of court life.

Queen Mary shared his practical interest in household matters, and their zest in rebuilding and refurnishing much of Hampton Court Palace, indicates the trend of their tastes.

[2] "Little Books about Old Furniture—The Period of Queen Anne," by J. P. Blake & A. E. Reveirs-Hopkins. Published by Frederick A. Stokes, New York, 1911, pp. 14–15.

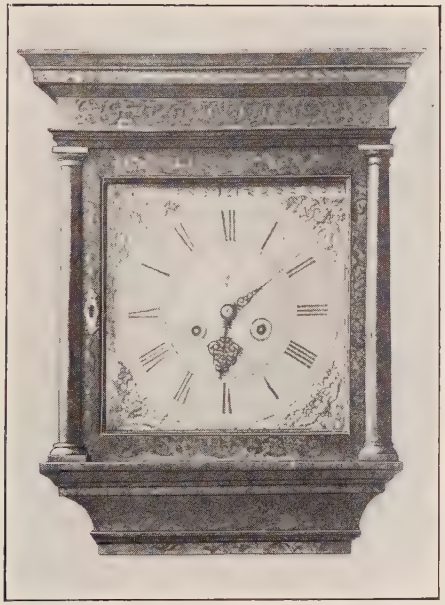

Illustration 18. Long Case Clock, inlaid with fine arabesque marquetry, of dark wood in a ground of sycamore. Date about 1705–10.

Illustration 19. Table decorated with floral marquetry, reminiscent of the Dutch, the groundwork overlaid with panels and borders of cross-cut veneer. Top detail shown above.

Mary it was who started the fashion of collecting Chinese porcelains, which rapidly became such a fad that it established the necessity of building china-closets to accommodate the exhibits. Various other pieces of furniture came into being, as the habit of quiet home life demonstrated the utility of certain articles for domestic uses. Bureaus, long-cased clocks, double chests of drawers or tallboys, mirrors for toilet tables and wall decorations, powdering stands and washstands were among the number. Comfort, suitability and simplicity of form were prime requisites. The character of the furniture is analyzed in the following comment of Percy Macquoid:

> No doubt the plainness of the furniture was in some measure due to the reduced finances of the nation, impoverished during the greater part of William's and Anne's reigns by wars that not only exhausted the resources of the people, but paralyzed trade, the latter being so restricted for a period that the number of self-made merchants of former times who had so ostentatiously and lavishly spent money on furniture and decoration was now greatly reduced. Retrenchment and economy became a necessity among many of the county families, and consequently a certain mediocrity of imagination and general lethargy in art became universal, and with the exception of the few very wealthy landowners, the community was content with less luxurious surroundings.[3]

In spite of this, the authority does grant, however, that for good workmanship and neatness of design, the period is worthy of note. He writes:

> A very large number of English cabinet-makers and artisans existed by the manufacture of high-class furniture, and these numbers were continually supplemented by talented French craftsmen, who sought the protection of this country against the religious intolerance of their own.[4]

As marquetry was one form of decoration in high favor among the Dutch, it continued to be used on furniture pro-

[3] Macquoid, Vol. II, p. 157.
[4] *Ibid.*, Vol. II, p. 64.

duced in England under Holland workmen and inspiration. (See Illustrations 18 and 19.) Macquoid explains the change taking place in this decoration as being due to the contributions of the two countries which are highly regarded as the source of inspiration in art:

> Italy supplied the real suggestion of color for inlay in stained woods, whilst France, in exiling her workmen, introduced the patterns of Boule, which was the later development of this highly decorated style.[5]

The chief interest of the period lies in the common use of plywood, when walnut veneer was used to finish and ornament every type of furniture, as shown in Illustration 20. During the period of Dutch influence, everything was veneered, and form was subordinated to color. Macquoid, in his study of English furniture, presents piece after piece of plywood construction veneered in walnut. The plates are too numerous to reproduce here, but from the volume of evidence, it must be conceded that furniture, still cherished in the collections of museums and in private collections of titled noblemen and ladies of high degree, not only bears witness to the splendid workmanship of the late 17th and early 18th Centuries, but also to the enduring quality of plywood and of veneer.

An early example of high class, simple walnut furniture is pictured in "The Age of Walnut," with this description of the plywood construction:

> The doors are veneered in oyster pieces of walnut with a lighter border of the same wood; the drawers are faced in a similar manner, but edged with a chequer of holly and ebony.[6]

A later cabinet, shown, has the walnut veneer cut on the straight, and the outside of the doors inlaid with oyster pieces.

One dressing-table, pictured, is typical of the adoption of plain bedroom furniture, which was general towards the end

[5] Macquoid, Vol. II, p. 117.
[6] *Ibid.*, pp. 159-160.

Illustration 20. Bureau, veneered with walnut, showing the sloping folding top which came into use at the beginning of the 18th Century.

Illustration 21. Queen Anne Chest of Drawers, veneered with walnut.

of the 17th Century. It is of walnut, plywood construction throughout, and has a "herring-bone" inlay of the same wood bordering the drawers.

China cabinets had fronts of marquetry or cross-banding of walnut on the door frames.

From Holland came the idea for the useful wardrobes, plywood built, "usually oak and pine veneered with walnut" and often decorated with elaborate designs in marquetry.

An innovation is noted in a writing-cabinet supported by a chest of drawers, the ornamentation of which is described as follows:

> The frieze of ovolo shape is inlaid with the usual two panels, and below this a large and heavy flap of oak veneered with walnut and marquetry lets down, disclosing a series of eleven inlaid drawers.[7]

Lace boxes varied only in the character of the veneer applied, which conformed to that of the chests of drawers on which they were designed to stand.

One such plywood piece pictured by Macquoid has "drawers veneered with a facing of good figured walnut, and edged with a 'herring-bone' inlay of the same wood." Another has drawers "veneered with 'tiger' walnut and cornered with a narrow inlay of ivory and ebony." Of a third chest of drawers, it is said simply that "the walnut is exceedingly dark." Illustration 21 is typical.

A "dwarf chest of drawers" is reproduced to illustrate the "amount of labor expended by the craftsmen of the day upon the early examples of veneering. On the face of the top drawer alone, there are no less than twenty large and thirty-three small pieces of veneer, exclusive of the bordering."

Claimed as typical of late 17th Century pieces, when "ovals and other patterns of marquetry are set into finely ground or matched surfaces of veneer," is a walnut inlaid writing-cabinet, pictured with the popular fine seaweed pat-

[7] Macquoid, Vol. II, p. 55.

tern (see Illustration 22) and described as "veneered in plain walnut, with panels of dark marquetry on a light ground."

In the English lacquer furniture, well liked in the last of the 17th and early in the 18th Century, "occasionally a buff ground was introduced to imitate the light sycamore ground of marquetry."

The reign of Queen Anne began in 1702, and Macquoid writes of the arts in her reign:

> After the death of Queen Mary, the Court for a time lost all elements of brightness and polish, and Anne, on her accession exercised no personal influence upon the arts of her day, her preferences, being confined to domestic duties, dress and the free indulgence of a healthy appetite. Her somewhat lethargic temperament was typical of the people who surrounded her at a time when all enterprise in art, save in light satirical literature and music was neglected for place hunting, purposeless political party-feeling, cards and tea parties; the interests of the nation being divided between the war with France and State lotteries.[8]

Queen Anne chairs are familiar in present day reproductions, of which the cabriole leg is a distinctive feature, as of tallboys, lowboys and tables of the period.

This reign was "a drinking, gambling and dice-throwing age," and it is amusing to read of the trivial excuses for wagers of startlingly large proportions among young coxcombs of the day. To these habits we are indebted, however, for the card tables and other game tables which were devised to meet current usage. Many were decorated with marquetry. Occasional tables were inlaid with pear, sycamore, maple and cherry.

A double chest of drawers, a favorite piece of furniture from the beginning of the 18th Century, is pictured by Macquoid with "the center of the semi-circular frieze inlaid with a cross and square in dark wood on a shield of lighter ground;

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[8] Macquoid, Vol. II, p. 243.

Illustration 22. Inlaid Writing-Cabinet of bleached walnut veneer, showing arabesque marquetry in seaweed pattern, characteristic of William and Mary days.

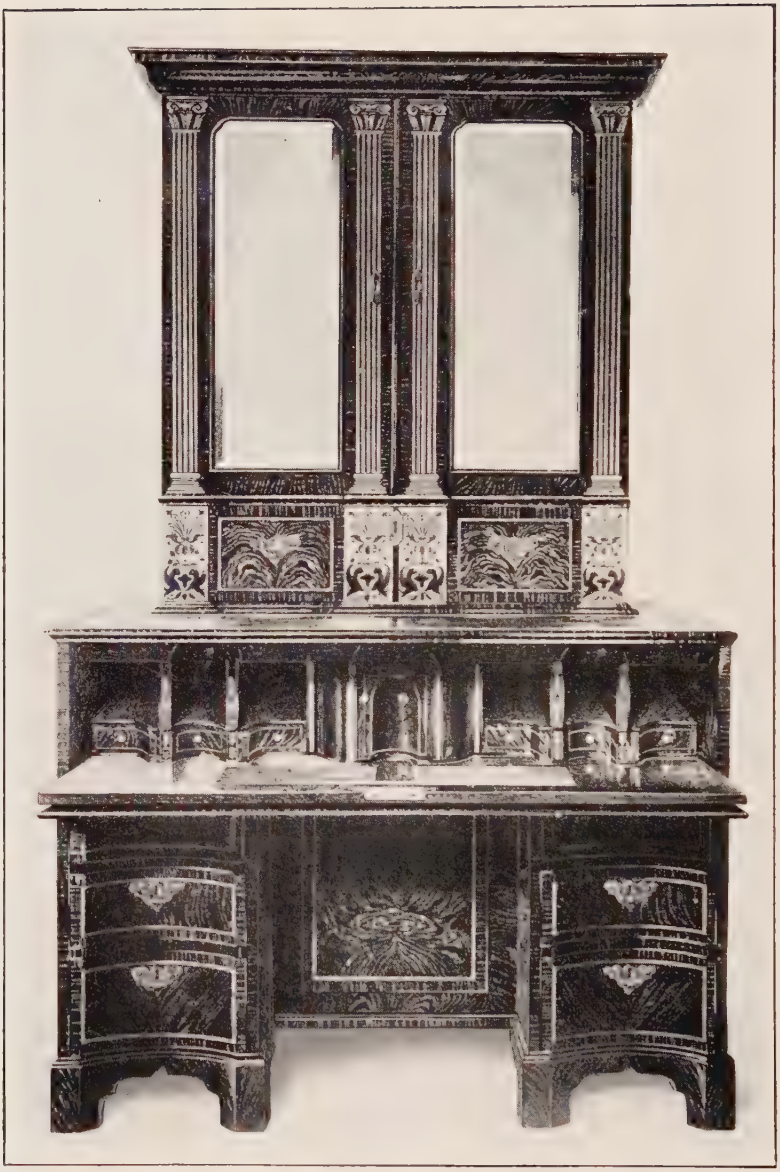

Illustration 23. Dean Swift's Writing-Cabinet, richly veneered with walnut and marquetry and bandings of ebony and holly.

the face of the piece is veneered in burr walnut, each drawer being bordered with a cross-banding of the same wood."

"Cases of grandfather clocks in the main, harmonized with the other furniture of the period," according to Macquoid. "Many were veneered with walnut and others (more rarely) with ebony."

He describes a beautiful escritoire of the period, plywood built of "red deal overlaid with thin veneers of walnut and fine knotted pollard oak of dark hue, with cross-banded edges of walnut in various shades." Other specimens are entirely veneered with walnut and still others, inlaid with marquetry.

No more perfect specimen of rich walnut veneered furniture exists than the famous writing-cabinet of Dean Swift, dated about 1710, shown in Illustration 23.

Macquoid says:

> It is veneered with walnut and surmounted by a plain cornice; beneath which are two doors filled with crystal cut looking glass and two drawers; these are framed in four pilasters of marqueterie in ebony and holly, the plinth being inlaid in a design of sphinxes and conventional ornament. . . . Drawers of concave frontage are banded with lines of ebony and holly.[9]

Here, probably, were indited the "Letters to Stella"; here also, in imagination, were described the scenes of Captain Gulliver's immortal Travels.

An interesting exposition of the matching of veneers occurs in Robinson's comment on this period, verging on the "Age of Mahogany," which reads:

> By the process of taking two very thin sheets out of the same piece of wood and placing the first one way and the second the other, as the pages of an open book, beautiful effects of opposition of grain are to be obtained. This process, however, was not common, except perhaps in the case of walnut-veneered furniture, until the mahogany period. Large pieces

[9] Macquoid, Vol. II, p. 239.

of this fine-grained wood could be treated in this manner to advantage, as it will take a polish infinitely superior to that of the coarser-grained woods.[10]

A chest of drawers, typifying the style of the period, is the "Lost Treasure of Windsor," a magnificent restored piece, dating back to 1685, resurrected from the debris of a neglected ruin in Hampton Court Palace. It is considered a classic of the veneerer's art and is still preserved at Windsor Castle, as the "Treasure of the King." (See Illustration 24.)

It is described by Guy Francis Laking as follows:

A small chest of drawers, that at pleasure rests on the top of the table; this stands on six inverted acorn-shaped feet. Either end projects slightly, and contains two drawers; in the center is a large drawer, with three smaller drawers beneath (one of which is fashioned to represent two drawers), and one contains compartments for an ink vase, etc.

The bodies of the two parts are on a foundation of pine-wood, with some of the principal parts composed of oak. The legs are of walnut-wood. The whole is veneered with walnut-wood, and enriched with an elaborate marqueterie of hollywood. To describe the design chosen for its enrichment is somewhat difficult, for every form of scroll-work elaboration is used. This is in places varied with strap-work, curious attenuated monsters, shell-like forms, and, as already stated, the crowned monogram of William and Mary in the center, the marqueterie of the crown being enriched by the addition of mother-o'-pearl. With the exception of the back of the table, not one portion of the piece of furniture is left undecorated, even the various edges having their due allowance of scroll-work.

The school of decoration under which this curious enrichment could be placed has as yet no direct name, for it seems derived from the scroll and strapwork seen engraved upon English plate of the last years of the 17th Century, notably in the works of Peter Harrache and John Croker, but produced under Dutch influence, which has in some places stinted the vigour of the scroll work to a certain degree of

[10] Robinson, p. 169.

Illustration 24. "The Lost Treasure of Windsor," entirely veneered with walnut and enriched with elaborate marquetry of hollywood.

tameness. The charm of its "sunny" colour happily overcomes this failing, for in the general view of the whole much of the detail is lost, the defects of drawing being only noticeable on a close examination.[11]

[11] "The Furniture of Windsor Castle," by Guy Francis Laking. Published by Bradbury, Agnew & Co., London, 1905, p. 25.

# CHAPTER VII

## VENEERING OF MAHOGANY AND SATINWOOD IN THE GEORGIAN PERIOD (1720–1820)

In the Georgian period, which extends through the reign of George III in 1820, the styles of furniture changed, with the rise to prominence of one cabinet-maker after another. In this period, names of master designers, Chippendale, Adam, Hepplewhite and Sheraton, distinguished the styles, rather than names of ruling sovereigns, as had been the general custom in the past.

This epoch is known for the decline in the use of walnut, which had captivated popular taste in Queen Anne's day and definitely established the general use of veneer and of plywood, and for the ascendancy of mahogany. This wood came into exclusive favor for solid work in the time of Thomas Chippendale, when the repeal of the tax on imported timber stimulated its more general use. The previous use of mahogany had been confined to veneer, as the solid wood was expensive, in addition to being "hard to manipulate."

Percy Macquoid's volume on "The Age of Mahogany" acknowledges "properties of lightness in mahogany unknown in oak, and durability and strength deficient in walnut," as well as the novelty of the warm color of this wood from the West Indies.

He goes on to say:

> It has been shown that toward the end of the 17th Century, decoration on furniture was principally represented by marqueterie or different processes of veneer, for the elaborate carving in soft woods, gilt or painted, was chiefly used for console-tables, mirrors and beds. The early mahogany furniture of 1715 was solid and simple, and consisted princi-

pally of chairs, stools and settees, the decoration on these being generally confined to a shell on the shoulders of the leg, with some slight ornamentation over the splat. The true spirit of the age of mahogany did not commence till about 1725 and terminated about 1770, when inlaying once more came into fashion.[1]

The date 1770 opens "The Second Period of English Veneer," of Mallett's classification, in which Adam, Hepplewhite and Sheraton, all advocates of the plywood principle in the production of fine furniture, were the leading figures. Macquoid notes characteristics common to the three:

Plain panels of wardrobes and cabinets, enlivened in the three former reigns with marqueterie, were now enriched with mouldings and framed in carving and decorated borders, and furniture as a whole became lighter and smaller in character.[2]

## Thomas Chippendale

From 1750, or earlier, and continuing through the year 1780, Chippendale was the cabinet-maker and upholsterer patronized by the leaders of fashion and of society, the class whose preferences in taste have in every age established the customs and buying habits of the great majority. This power of leadership is a psychological factor that always may be counted upon in catering to the general public in the manufacture and in the sale of any generally used commodity.

Dyer pays tribute to the genius and versatility of Chippendale in these words:

Chippendale was a wonderful adapter of styles, obtaining his inspiration from various sources. He was remarkably versatile. His was the ability to combine inconsistent elements in a harmonious whole. His workmanship and skill as a carver were of the highest order. His designs were

[1] Macquoid, Vol. III, pp. 262–263.
[2] *Ibid.*, p. 3.

> daring, and varied from the bizarre to the exquisite. They ranged from the Dutch school of the early Georgian period, through the Rococo of Louis XV, the Chinese and Gothic fads, finally leading up to the Classic and Louis XVI.[3]

Walnut, maple, cherry and birch were not unknown in furniture of this age, but the wood preeminently suited to Chippendale's patterns was mahogany. (See Illustration 25.) Chippendale's design, being based on form, rather than color, in the main required the extensive use of solid woods rather than veneers.

That this master fully appreciated the superiority of plywood for certain types of construction, however, and that he had full confidence in its strength and durability, is the inference of one authority. (See Illustration 26.) From a careful study of Chippendale's designs, Robinson writes:

> Chippendale was not satisfied with the mere natural beauty of mahogany. He did justice to its merits by the conscientiousness of his constructions. His frets were no mere pierced planks, but consisted of several thicknesses glued together in different ways of the grain, until the result was ornament capable of withstanding climatic changes and the effect of time to an extraordinary extent.[4]

In commending the response of Chippendale to the demand for lighter and more elegant furniture, Hunter brings in this thought:

> The introduction of wall paper and the elimination of heavy interior architectural and sculptural forms in wood and plaster naturally demanded chairs and furniture of an entirely new type. . . . English furniture of these periods shows more natural wood, and less marquetry and less gilding [than contemporaneous periods in France].[5]

Macquoid, on the other hand, specifically mentions the combination of mahogany with gilt about the middle of the

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[3] Dyer, pp. 111–112.
[4] Robinson, p. 243.
[5] Hunter, pp. 352, 354.

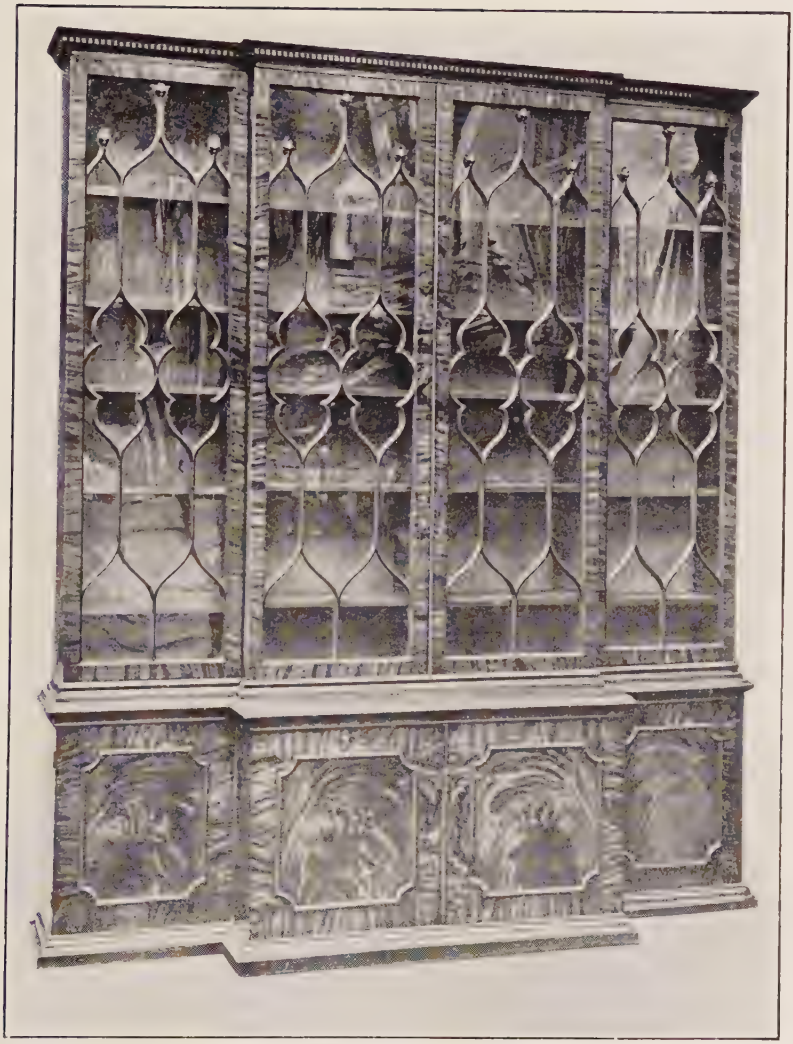

Illustration 25. Chippendale Bookcase, veneered with fine crotch mahogany.

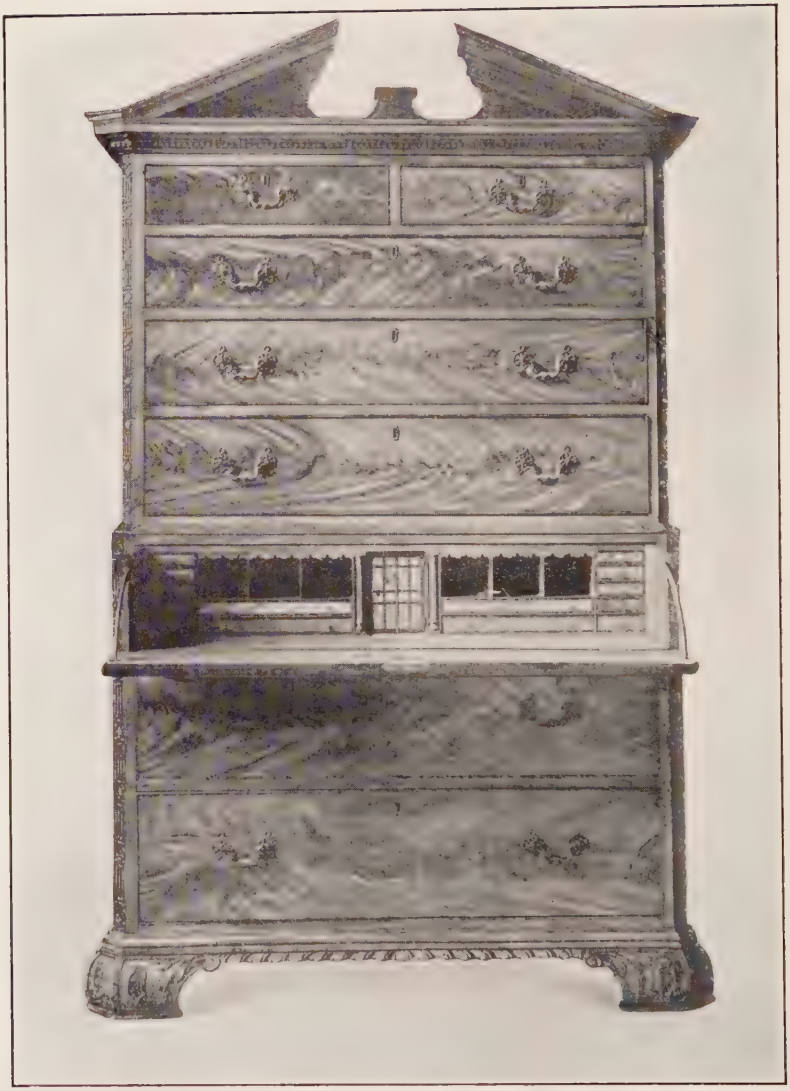

Illustration 26. Secrétaire and Double Chest of Drawers, veneered with choice crotch mahogany, and satinwood, with outside edges veneered with rosewood.

period. The opulent taste for ornate gilt tables with glass or marble tops and gilt chairs with ornamental cabriole legs showed the influence of the lively French court of Louis XV.

As a specimen of the time when "elegance of line and form began to supplant the picturesque and more solid designs" of the early years of mahogany, is an unusually fine cabinet of plywood construction, pictured by Macquoid and described as follows:

> This was probably made by the firm of Chippendale between 1750 and 1760 and is a masterpiece in construction, design and execution. The motive is Chinese and the beauty of the undulating lines of the front is only equalled by the perfection of the veneer and the tasteful arrangement of the woods employed. . . . The doors are veneered on the outside with fine amboyna wood, bordered in light rosewood, inlaid with a herring-boning of ebony and holly, the insides being veneered with plain panels of light rosewood; these doors open on a series of ninety-three drawers, faced with walnut, mahogany, amboyna, satin, laburnum, rose and other woods.[6]

According to Macquoid, after 1775, mahogany writing-cabinets were found veneered with satinwood. He devotes an entire volume to the furniture (much of which is veneered) of what he calls "The Age of Satinwood."

Commodes are sometimes inlaid, with front and sides of veneer. One with three drawers is "decorated with coarse inlay of mahogany and satinwood on a sycamore ground"; an upright writing commode, belonging to a set of veneered and inlaid satinwood furniture made by Chippendale and designed by Adam, has "inlaid black ovals on the door, and green in the surrounding inlay, and golden satinwood"; an inlaid commode has the "inside veneered with Hungarian ash, stained grey, much resembling watered silk of that color, then so fashionable."

Shown as typical of the designs of the end of the century,

[6] Macquoid, Vol. III, pp. 172, 175.

is a lady's writing-cabinet of satinwood, plywood built, which is said to be "entirely dependent for its decorative charm on the lustre of the veneer and perfect simplicity of its shape." Another with veneered ground "of the finest satinwood" was designed by Adam and executed by the firm of Chippendale. That veneer endures the test of time, is the thought predominant in the description accompanying this plate in Macquoid's book:

> The concave lunette forming the knee-hole is a masterpiece of cabinet-making, being composed of narrow mahogany staves shaped barrel-wise; on this curved surface, the veneer and inlay has not moved since the piece was made in 1773.[7]

An inlaid rosewood writing table of the Chippendale school is also pictured, and another of "pollarded oak."

In bringing out what comprised practically the first furniture catalogue, under the name of "The Gentleman and Cabinet Maker's Director," Chippendale "broadcasted" his designs. This book sold for a sum equal to $16 a copy, an astonishing price in Georgian days.

## Robert and James Adam

In any furniture review of the Georgian period, the influence of Robert and James Adam must be acknowledged, architects though they were, and not strictly of the group of cabinet-makers. They designed and created furniture only in so far as they deemed it necessary to complete the harmony of their rooms, where they sought to make every appointment uniform in design—tablecloths, carpets, walls, ceilings, mantelpieces and doorknobs.

From the prompt adoption of Adam lines and characteristic ornament, it is demonstrated that the Adam Brothers made a profound and permanent impression on artistry of furniture design.

[7] Macquoid, Vol. IV, p. 58.

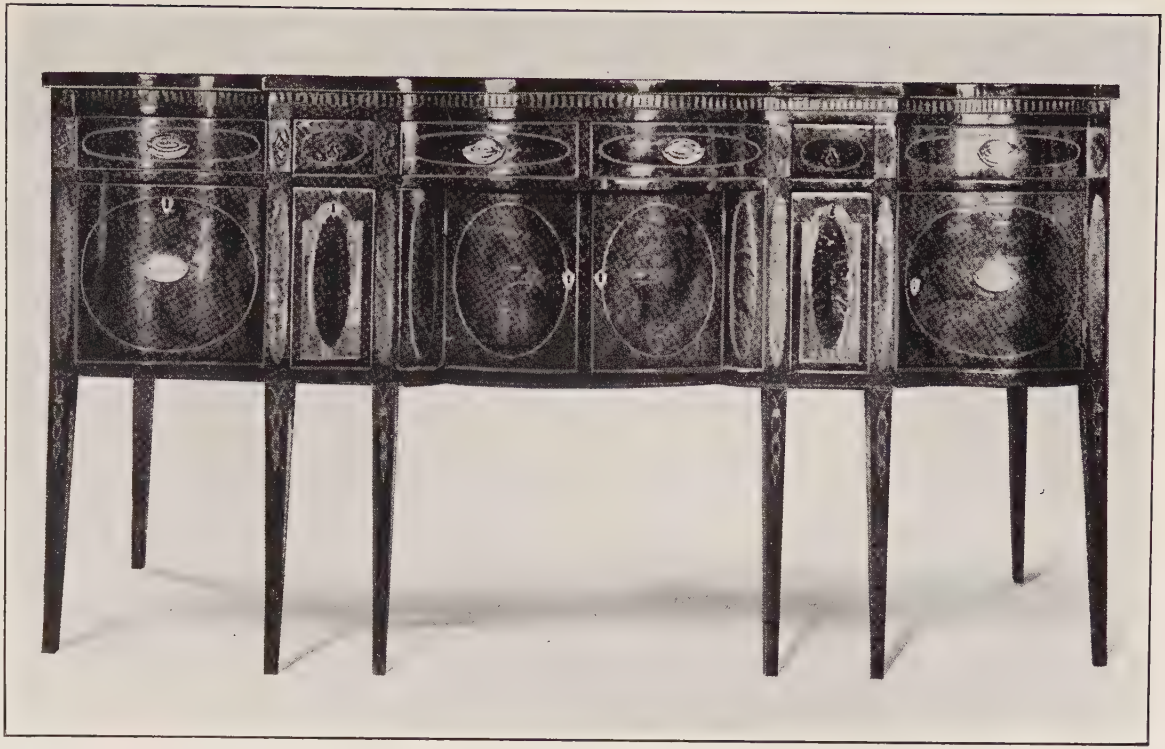

Illustration 27. Hepplewhite Sideboard, of mahogany veneer, bordered with hollywood.

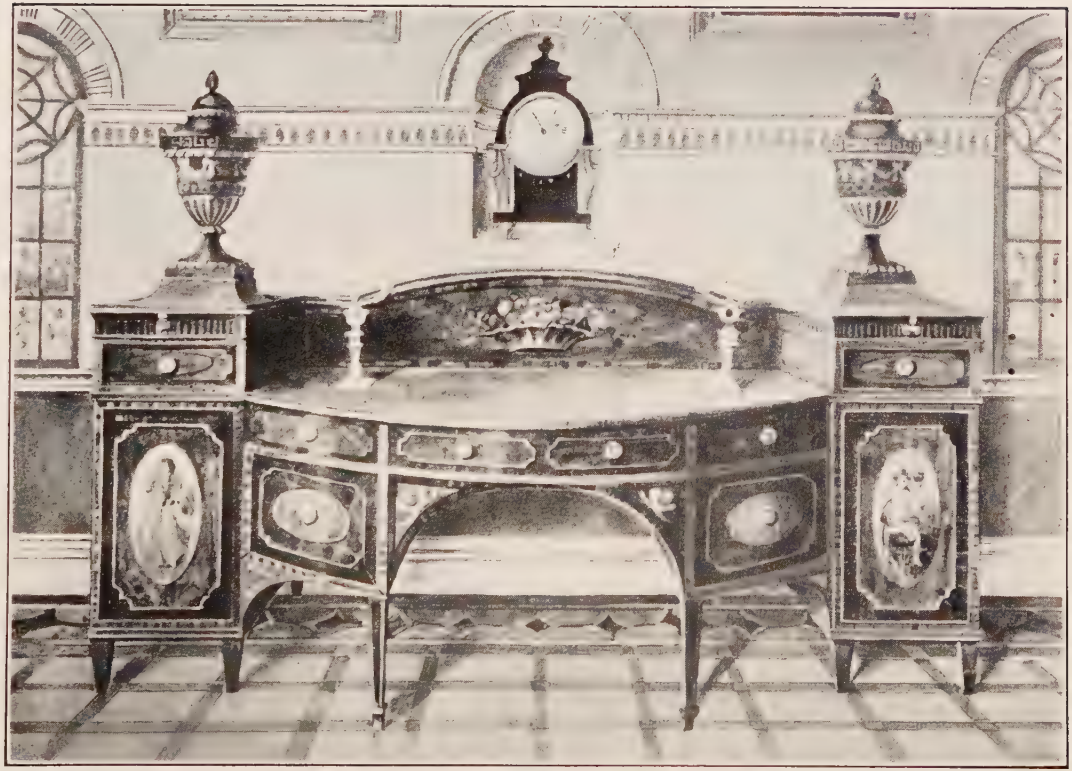

Illustration 28. "The Sideboard of the Bank of England," by Shearer, veneered with satinwood.

Nor should they be omitted in the list of those important in the history of veneers and of plywood, for in their time, taste again reverted from solid furniture to that enriched by color. Inlay was an integral part of many Adam designs, and satinwood veneers were a favorite finish. In writing of this phase of the Adam styles, Hunter says:

> The earlier inlays of the Adam period were on a large scale—classical heads, human figures, broken columns and vases. As the style progressed, the inlays became delicate, consisting principally of thin honey-suckle ornament and foliated scrolls, and above all else, fanleaved discs and ovals.[8]

Macquoid says of the process:

> At first the inlay introduced was comparatively simple, but shortly became more elaborate, being occasionally distributed over the surface of the top.[9]

The plates in this connoisseur's volume on "The Age of Satinwood" indicate plywood construction in many cases, and further, that even with the extensive use of inlay of rare woods, mahogany was still employed. A cupboard, reproduced, has "fronts veneered with clouded mahogany on a satinwood ground." A clothes press is included to illustrate the veneered and inlaid type, in what is said to be "probably a light colored variety of mahogany, possessing the ripple and lustre of satinwood, but more open in the grain." Macquoid also shows a mahogany veneered and inlaid sideboard table "with urns and pedestals of plain mahogany, inlaid with the same wood of a lighter color." A wardrobe of plywood construction is described as follows:

> The panels are veneered in East India satinwood of fine lustre, bordered with the same, cut on the cross and edged with tulipwood. The veneer on the drawer fronts is of partridge-wing satinwood and of a fine, rich gold throughout.[10]

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[8] Hunter, p. 355.
[9] Macquoid, Vol. IV, pp. 92, 94.
[10] *Ibid.*, p. 150.

The Adam style is distinguished more by its ornament than by its structure, and the details are familiar to us in popular present-day reproductions. The urn, the lyre, the architectural motifs, such as the Ionic capitals, and the draped classical figures are all of Adam origin.

An apt description is quoted from Dyer:

> The Adam style is characterized by simplicity and delicacy, elegant slenderness, and fine proportions. Carving, when used, was in low relief. The later work was rich in inlay of tulipwood, satinwood, and ebony, and some of it was painted. Carving and inlay were in classic details—the urn, the laurel wreath, the oval sunburst, the acanthus leaf, arabesques, ribbon bands, festoons and garlands.[11]

In the opinion of Clifford, the work of the Adam Brothers reflected the very spirit of classic Italian art, in type even purer than the Louis XVI adaptations of a slightly later date. In reviving the classical influences, the Adams introduced not only new decorative motifs but also radical changes in the forms of furniture. Their graceful, straight lines were inspired by the art uncovered in the buried city of Pompeii, an event which caused the same stir in the 18th Century as has the discovery of Tutankhamen's tomb in the archaeology of the present day. Bulletins are now sent by radio and cable, direct from the Egyptologists to the newspapers, which regard the latest disclosures in Cairo as worthy of valuable front page space. In such manner does science or art become "news" and a subject of popular discussion. Gradually the dissemination of these fresh ideas becomes a part of public consciousness to such an extent that they find expression in new art creations.

## George Hepplewhite

Still another Georgian master of the craft of fine furniture, who used veneers and the plywood principle of construc-

[11] Dyer, p. 117.

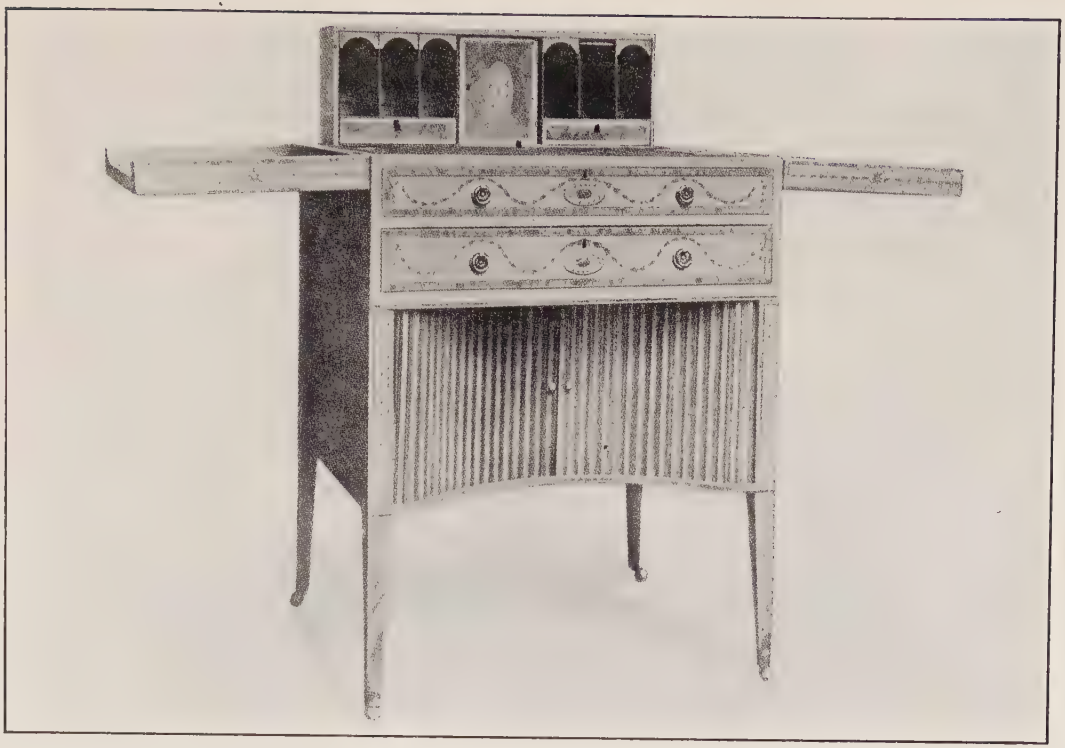

Illustration 29. "Harlequin Table," by Sheraton, veneered with West India satinwood, inlaid with green marquetry and ovals of engraved holly.

Illustration 30. Veneered Bookcase and Side Table, by Sheraton.

tion, was George Hepplewhite. His work began to attain popularity about 1765. The pieces which he designed and built, emphasized beauty of line, following the curve of Chippendale more freely than the straight lines which were beginning to return to favor. "The Cabinet-Maker and Upholsterer's Guide," his posthumous book of designs, shows in almost every drawing that the plywood principle had become the dominant factor in the designing of fine furniture. These designs are still standard. The contemporary influences of Adam and Sheraton, with their classic lines, are noted, as well as the dainty grace of the French of Louis XVI and Marie Antoinette.

It has been said that there are few styles to which modern designers owe so much as to the Hepplewhite. A typical example is the sideboard shown in Illustration 27, plywood built in 1795—mahogany veneer, banded with hollywood. Even the legs are veneered and embellished with delicate marquetry. For the present-day form of the sideboard, Hepplewhite divides honors with Shearer, whose artistry is exhibited in Illustration 28, a superb classic of plywood construction, the famous satinwood veneered "Sideboard of the Bank of England." Hepplewhite is also known for the originality of his shield-back chairs, in which the cabriole leg is forsaken for the square, tapering variety. His wardrobe supplanted the tallboy for general use, which former, in characteristic fashion, was treated particularly from a decorative standpoint. Blake and Reveirs-Hopkins describe one of the Hepplewhite wardrobes "with matched oval panels of beautifully figured mahogany veneer, outlined with bands of herring bone inlay, which are repeated in the drawer fronts." Macquoid pictures a clothes press "with door panels inlaid with tall shields of a light colored mahogany on a darker ground."

Like Chippendale, it is noted that Hepplewhite found the strength and figure of mahogany best suited to his designs, but more than his predecessor, he realized the advantages of

lighter materials, satinwood, rosewood, etc., to meet special demands. Likewise, during this period, plywood construction was in general use. One handsome sideboard reproduced in a plate of Macquoid's has the entire surface veneered with satinwood. Other sideboards are veneered and embellished with a delicate inlay of the satinwood or of tulipwood, rosewood, sycamore, maple, yew, ebony or holly. Plain wood was elaborately painted and gilded to raise it to the standard of elegance desired.

Designs frequently seen in his carvings and other forms of ornamentation are the lyre, the urn, the honeysuckle and the Prince of Wales feathers.

To Hepplewhite, then, we are indebted for a gradual evolution from the massive and the heavy, to those lighter, more airy and graceful forms that still bear his name.

Macquoid brings the shadow of an adverse note into his evaluation of this cabinet-maker when he says:

> The carving of Hepplewhite is delicate and his inlay careful, but both are lacking in life and spontaneity. The finish is admirable and the construction of his furniture scientific in its lightness and durability, but the results are seldom unexpected.[12]

## Thomas Sheraton

The last of the famous line of Georgian cabinet-makers, who stamped this as "the golden age of furniture making," is Thomas Sheraton. "With Sheraton, the development of English style in furniture properly ends," says Dyer, "for after him came confusion, followed by the heavy, graceless forms of the 19th Century." Sheraton is rated by many authorities as the most artistic of them all, and is distinguished in the history of veneers and of plywood as "a master of inlay."

His "Drawing Book," published in the last decade of the 18th Century and abounding in complicated problems which

[12] Macquoid, Vol. IV, p. 76.

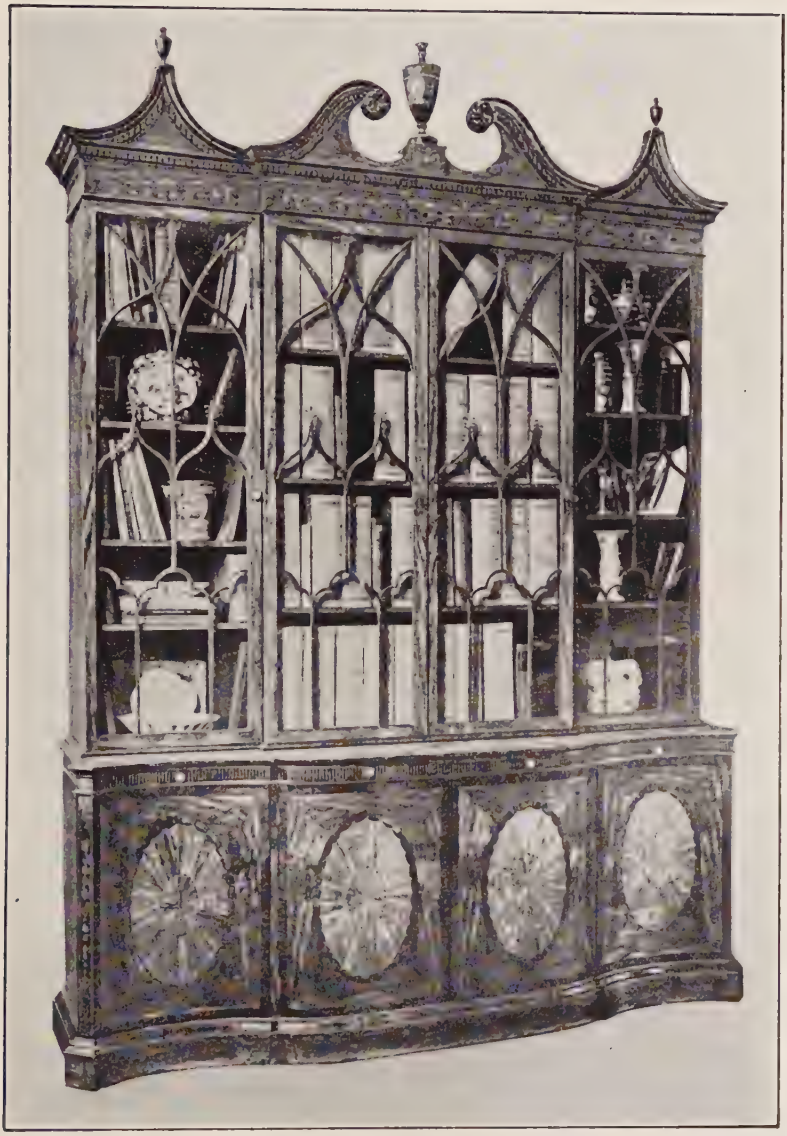

Illustration 31. Library Bookcase, veneered with Cuban mahogany and inlaid with satinwood.

Illustration 32. The Celebrated Bookcase of veneered mahogany, designed by Sheraton for *The London Times.*

he applied to furniture and the decoration of rooms, is still consulted by furniture designers the world over.

Singularly versatile in mechanical skill, Sheraton made furniture which exhibits remarkable ingenuity in its convertible devices. One had only to press a spring in order to change an ornament of the drawing-room to a necessity of the boudoir. (See Illustration 29.)

In the opinion of Dyer, Sheraton, at his best, was "unsurpassed for delicacy, grace of proportion, and restraint." Sheraton styles are rectangular, with high, perpendicular outlines. The general impression given by his furniture is that of slender delicacy. Yet it is fundamentally sound in construction. Sheraton was strongly influenced by the French, and cleverly adapted to comfort and convenience, the tendencies of the Louis Seize furniture.

What is more, he gave much to modern decorative design, among the motifs being the oval, the star and other geometrical shapes, the lattice, the wreath and the fan. (See Illustrations 30 and 31.)

Blake and Reveirs-Hopkins, in their book on Sheraton, have illustrated from different collections, example after example, showing his mastery of woods in the fine art of veneering. Satinwood, kingwood, sycamore, and green-stained whitewood are all shown in combination with mahogany. Cabinets, veneered with satinwood are presented, some with painted designs. Dressing-tables are veneered with satinwood, and one, described as typical of Sheraton, is "inlaid with strings and bands of satinwood." One illustration is that of a two-flap table of mahogany "with running border in satinwood inlay." A similar table has a low pillar base "veneered with mahogany and inlaid with bands of satinwood." A "tallboy" chest of drawers is "veneered with finely figured dark mahogany and lined with oak." A bookcase and writing chest of drawers is described as having "a veneer of satinwood, banded with fiddle-back mahogany." A lady's "workbox on

a stand" is of satinwood, "veneered and inlaid with darker woods in floral design."

Celebrated throughout the "realm of good furniture" is the Sheraton veneered bookcase, designed for, and still in the possession of *The London Times.* This famous classic, almost a sacred shrine to the devotee of fine furniture, is finished throughout in mahogany veneer, the rich effect of which it is only possible to suggest in the reproduction in Illustration 32. In the foreground of the picture is a veneered table and petit stand, and in the corner a clock to match. All are of veneers of mahogany, well over a century old, but intact today, and beautiful in their pristine perfection—thanks to the art of plywood construction and of veneered surfacing under the master hand of Sheraton.

"Solid" pieces, of such delicate design as these, in all human probability would have warped themselves to oblivion long years ago, but plywood and veneer are processed to resist heat and moisture and the damaging effects of time.

# CHAPTER VIII

## VENEERS AND PLYWOOD IN AMERICAN COLONIAL FURNITURE

The New American Wing in the Metropolitan Museum of Art in New York, opened early in 1925, affords excellent opportunity for the study of colonial furnishings. Entire rooms have been transplanted from their original settings—even to the woodwork, pegged floor-boards and wall-paper. In the impetus given the sentiment of "American things for American people," is discernible the growing interdependence of both the manufacturer and the art museum.

The term Colonial is extended in this chapter to apply to all American furniture up to about 1840, although literally it should be confined to the products of the Colonies before they gained their independence. Household effects, in the pioneer settlements, were brought over from the Old World and naturally represented the styles current there at the time. Later furnishings depended for inspiration on advancing foreign fashions. Thus, we have to consider a succession of styles, Jacobean, Queen Anne, Georgian and Empire. Not only did the pieces carried across the Atlantic exemplify these varying styles, but also the furniture made from imported patterns by resident cabinet-makers, who trailed a decade or so behind the inauguration of new styles in the mother country.

Further variation, due to environment and nationality of the settlers, is observed in the different colonies. New England furniture included almost all of the types brought into the country, as well as those of local make, and is still admired for its honest construction and for its artistic simplicity.

Imitations of Jacobean styles began with oaken chests, cupboards and settles, and were crude and plain, as might have been expected under pioneer conditions. By the time William and Mary fashions came to be the vogue, workmen had grown more proficient, and plywood came into general use in the making of highboys of walnut and in other creations of the period which required skilled artistry. It was in New England that the "tallboy" became a "highboy."

In time, Chippendale and other Georgian styles were reproduced, with this one difference frequently imposed by pride and independence of the Colonists—the substitution of bilsted, or sweet gum (also called red gum), for the mahogany which had to be imported from the British Colonies. Oak and walnut were also used for furniture and such native woods as pine, maple, hickory, elm, ash, cedar, cherry and birch.

Knickerbocker New York showed a predominance of Dutch influences, as many of the early pieces were brought there from Holland. In time, Cromwellian traces appeared, followed by inspiration from Chippendale and his contemporaries.

Pennsylvania was settled too late to show much of the massive Jacobean note, but William and Mary reproductions with their characteristic marquetry and inlay ornamentation, are seen repeatedly. Black walnut of the native forests was much in favor as a cabinet wood. Philadelphia soon commanded respect for superior workmanship, and came to be looked upon as a source of furniture supply for the aristocracy of the early South.

After the first hundred years in the Colonies, mahogany displaced the conventional oak in the making of fine furniture. In Delaware, the most important furniture was built of mahogany, in Georgian styles, with the usual embellishment of veneer, inlay and marquetry.

Originally, the South imported from Europe nearly all of its furniture, much of which has been allowed to perish.

French inheritance was strong in this region, particularly in Louisiana.

With the cessation of the constant struggle against the elements and the aborigines, which struggle had so imperatively occupied the Colonists during their first century of occupation, came leisure and attention to self-expression along artistic lines. In the employment of inlay and veneer for the furniture creations of the time, may be found adequate testimony that the decorative value of fine grains and varied colors of woods, was fully appreciated. Plates, in the books of such recognized authorities of the period as Luke Vincent Lockwood, Wallace Nutting and Charles Over Cornelius, are suggestive of the various types of Colonial furniture evolved. The accepted use of veneers and of plywood is demonstrated in almost every type.

Great numbers of sideboards were made after the designs of Shearer and Hepplewhite. Veneer of finely grained mahogany on whitewood was not uncommon for the drawers, doors and tops. Fine lines of holly and ebony outlined the drawers of some, and in others, marquetry of many colored woods took the place of inlay. Less common is inlay of dark and light woods in a block design, which appears on a panelled cupboard of the late 17th Century.

On writing-tables and secrétaires of Sheraton design, satinwood veneer for drawers and panels was frequently applied to the mahogany. As in dining-room pieces, a narrow band of holly or ebony was often used to outline the drawers. A novelty now seldom seen, is the slate-top tea-table, with a veneered border of walnut or applewood.

Highboys of plywood construction, of walnut or maple veneer, are among the precious pieces still preserved in excellent condition. Many have borders of herring-bone veneer. Chests of drawers with cupboard tops decorated both with carving and inlay were much in use toward the close of the century. Drawer fronts were veneered with walnut, sur-

rounded by herring-bone borders. Dressing tables of walnut veneer on whitewood are seen, and the handsomest and best made bureau of its time is described as "showing a swell front of mahogany with square and oval panels of satinwood, each outlined with a fine border of inlay of holly, rosewood and ebony."

There is romance in the origin of odd pieces of furniture, and the American Windsor chair in grace and variety, has so far surpassed the English as to be accredited solely to American chair-makers. There is an old story relating that George I took the idea for the original Windsor from a hand-made chair chanced upon in a cottage. The Windsor chair became popular in America in the latter half of the 18th and early 19th Centuries, and appeared in myriad forms—side-chairs and armchairs, fan-backs, low-backs, loop-backs, hoop-backs and comb-backs. Historical association makes the Windsor chair a special treasure, for it was in a Windsor chair that Jefferson was seated when he wrote the Declaration of Independence, and Martha Washington used Windsors at Mt. Vernon.

Cherished in this venerable Colonial mansion are many of the original plywood pieces. A Hepplewhite sideboard of crotch mahogany veneer was dear to the domestic heart of Martha Washington, and the mahogany chest in her room is plywood built. Of mahogany veneer, inlaid with satinwood, is a fine old harpsichord, which belonged to Nellie Custis, the adopted daughter of Washington. A mahogany side-table in the room that was hers is also of plywood construction. A desk and bookcase presented to George Washington by his mother was plywood built in England in 1689. Still in a fine state of preservation, these plywood pieces may all be identified by a visit to Mt. Vernon.

Also of historical interest and of significance in the story of veneers and plywood, are the desks presented in Illustrations 33, 34, 35, 36. The desk of George Washington, used

Illustration 33. Desk of George Washington—plywood built, the facings of satinwood veneer.

Illustration 34. William Penn's Desk—veneered.

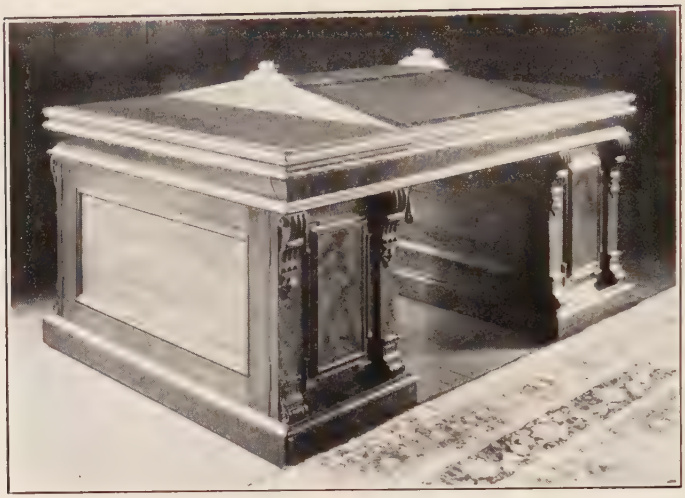

Illustration 35. The Daniel Webster Desk—made from exquisite mahogany plywood panels.

Illustration 36. Desk with veneered surfaces plywood built, at which Thomas Jefferson wrote the Declaration of Independence.

from 1789 to 1797, is plywood built and the facings are of satinwood veneer. The desk of William Penn is likewise veneered and the Daniel Webster desk is another splendid example of the durability of plywood. This last named venerated piece, of exquisite crotch mahogany panelling, has been presented to the United States Chamber of Commerce, whose headquarters is built on the site of the Webster family residence in Washington, D. C. The desk at which Thomas Jefferson wrote the Declaration of Independence is veneered. This has been purchased by Congress and is now one of the nation's priceless relics.

Late Colonial furniture, in which the Empire influence of France supplanted the Sheraton, is sometimes known as American Empire. Wonderfully grained crotch mahogany veneer was the usual material, applied in wide surfaces. Chairs, for the most part, were of veneered mahogany construction. Sofas showed plain surfaces of veneer. Tables grew heavier in design, but still used plywood tops and pedestals covered with fine veneers. Cupboard doors were often constructed with panels, plywood built, the face wood usually being of crotch or highly figured mahogany veneers. Bedsteads, picturesquely called "sleigh beds" for their rolling boards at head and foot, were generally plywood built, using facings of mahogany veneers, as only in this manner could the sweeping backward curves have been achieved.

Outstanding, for his superb interpretation of the artistic spirit of this age, is Duncan Phyfe, a Scotch cabinet-maker of New York, whose best work—executed before 1825—rivals that of Hepplewhite and Sheraton. Although his designs make no pretense of concealing contemporary English and French influences, yet he did develop an individual style of his own, which excites universal admiration for its distinctively American aspect. His inherent fondness for rich, finely grained woods is exhibited in his treatment of veneers and panels of plywood construction. By his use of broad surfaces of care-

fully selected woods, Phyfe demonstrated the truth that beautiful wood is in itself a decorative element. Earmarks of his works are certain oft-repeated details, among which are rectangles of contrasting woods in veneer. His masterly conception of proportion, his restrained taste and his tendency toward slim, vertical lines of delicacy were characteristic also of the architecture of the day and of woman's dress, which affected the long, high-waisted skirts and slim bodices.

So it is demonstrated that national designs are established, and the forms controlled to a great extent by the modifying influences of environment, in which social and economic factors blend with the artistic.

# CHAPTER IX

## VENEERING IN THE NINETEENTH CENTURY AFTER 1840

Artistic taste, which had begun to decline in the last years of Sheraton, seems to have disappeared altogether both in Europe and America about 1840. In the best of the preceding periods, architects had played an important rôle in designing furniture to conform to the styles of their interiors —furniture which would harmonize in general contour and proportion and which also would express the spirit and impulse which they wished to perpetuate in the furnishing and in the decorating of their rooms. In this period, good taste was subordinated to the struggle for originality.

Prior to this time, furniture had been fashioned by hand, by experienced designers and cabinet-makers who devoted to their work, not only a pride in craftmanship, but also in an artistry which is still a standard of excellence even to this day. Some time during this period, however, it was found that machinery could be used in the making of furniture, and there was an effort both in England and America to meet the opportunity created by this discovery. What followed during the next several decades was a flooding of the market with novel designs, which, to modern taste, were nothing less than monstrosities.

*The Furniture Trade Review & Interior Decorator* declares, in discussing this craze for novelties at the expense of taste:

> The "Empire" was certainly no improvement on the Georgian styles that preceded it. The Victorian was even

worse. Then came a flood of nameless things that culminated finally in the "golden oak" and Mission styles that are still seen in older homes, but not recalled with any degree of pleasure.

Unfortunately, at this time, the architects could only offer protest. Thomas Hope in England attempted to revive classical forms; Augustus Pugin tried to impose Gothic motifs; Eastlake did his best to recall the dignity of Tudor designs—all without serious effect on the runaway styles. William Morris (originator of the Morris chair) with his confrères in the "Sixties" did, however, mitigate to some degree the horrors that were being perpetrated on the guileless public. Together they established an ideal of craftsmanship which amounted almost to a cult, devoting to construction the same integrity which had inspired the craftsmen of medieval guilds.

At the height of this period of atrocities, it seemed that the object was to abandon all restraint and to achieve novelties as far removed as possible from the modes which had prevailed. It is astounding that taste which had reached so high a plane in the 18th Century in England, could have so deteriorated. There were no saving graces except sound construction and general utility.

As ever, the English turned to France for leadership in design. As one writer states, "it seems as though the English knew that their native art was not a flower of the first order of beauty and so were modest about it, and ever willing to adopt the art of other countries."[1]

But, in this period, instead of adapting French patterns to English environment, they extracted meaningless details with no discrimination, until the scrolls and curves of the rococo and the Empire symbols of triumph became distorted in the most incongruous patterns.

Litchfield remarks on the noticeable revival of marquetry, exaggerated as a feature of the time:

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[1] Candee, p. 22.

> Like all mosaic work, to which branch of industrial art it properly belongs, this kind of decoration should be quite subordinate to the general design; but with the rage for novelty which seized public attention, it developed into the production of all kinds of fantastic patterns in different veneers. . . . Partly on account of the difficulty in obtaining the richly marked and figured old mahogany and satinwood, which needed little or no inlay as ornament, and partly to meet the public fancy, by covering up bad construction with veneers of marquetry decoration, a great deal more inlay has been given to these reproductions than ever appeared in the original work of the 18th Century cabinet-makers. Simplicity was sacrificed, and veneers, thus used and abused, came to be a term of contempt, implying sham or superficial ornament.[2]

The Great Exhibition in London in 1851, sponsored by Prince Albert, popularized these execrable designs; it gave the stamp of royal approval, as it were, to the prevailing fashions of the Victorian Age.

Almost forty years later, the Paris Exposition attempted to introduce an artificial style known as "l'Art Nouveau," purporting to be founded on the flowing lines of nature. This mode was short-lived, for, as has been said, "it was not founded in the depths of artistic emotion."

The Philadelphia Centennial bore witness to the degeneration in our own 19th Century design. American manufacture had been in the hands of mere profit-seekers. Lumber was cheap and machinery made it possible to use unskilled labor. To meet the growing demand for furniture, hideous pieces were supplied that could in no measure approach the artistic productions of Colonial days, imitative of the sane and balanced designs of the 18th Century in England.

The mobiliary fashion following mahogany was rosewood, profuse in decorative detail. In time, this was superseded by black walnut, which in turn gave way to golden oak.

In the last decade of the century, the Mission style was

[2] Litchfield, p. 237.

avidly taken up in America, its straight lines and entire lack of ornamentation, a balm to spirits confused and bewildered by the multiplicity of useless gimcracks and gingerbread details, which had disfigured the furniture immediately preceding. Clifford has said that Mission represented, not so much a school of ornament as a school for the elimination of ornament.

The idea of the style came from the old Spanish Missions of California and Mexico and was inspired by the chance shipment of a chair across the country to New York. The Missions were crudely equipped by the old Friars, who constructed from woods and materials at hand what furniture was essential to meager comfort. They had in mind as the basis of their design the primitive Spanish styles of the 18th Century, which were Gothic in character.

Native ash and oak were the woods best suited to the requirements of this style, which reduced furniture to the stark, elemental strength of medieval days, unembellished by carving or the softening effect of fine veneers.

As the rage spread, an enormous quantity of machine-made Mission furniture was turned out. In its turn, this has now become an element of discomfort in homes where beauty is valued as an adjunct to utility. It is still so commonly seen that its square outlines and its heavy plank effects need no illustration.

This entire period under review was unfavorable to the arts. Progress was retarded for approximately thirty years by the Civil War, and encouragement was offered to mechanical, engineering and scientific achievements, rather than to labors in the field of art. As in other periods when art was at a low ebb, the art of veneering suffered a marked decline.

Only toward the close of the century did a new cycle of artistic taste become a factor in production. Manufacturers awoke to the need for a standard of craftsmanship. They realized the opportunity of creating furniture to suit individ-

ual preferences and the social needs of modern home owners. Treasures from the Old World, collected by Americans of wealth and leisure, served as models for local designers. The natural beauty of wood was again conceded its true value, with the realization of its dependence upon veneers for its highest and most brilliant accentuation.

The Chicago World's Fair, in 1893, marked the ascendancy of artistic standards and the return to the making of furniture of character in this part of the world.

# CHAPTER X

## TWENTIETH CENTURY TENDENCIES IN SOLID AND IN LAMINATED WOOD

The first quarter of the 20th Century showed evidence of a steady advance in artistic taste, which in the last decade of the 19th Century, had already begun to recover from its woeful debauch and its long sojourn in the wilderness of inartistic production. Simplicity and quiet elegance are the dominant notes in the best house furnishings of the present day. While modern manufacturers cater to luxurious comfort, they also recognize the need of furniture designs which shall meet the higher standards of art, consequent upon more liberal education and broader mental outlook.

Furniture dealers testify that in the majority of cases it is women who do the selecting and the buying of home furnishings, and the primary consideration, even before price, is that of appearance or design. The necessity of matched veneers, used for the purpose of beautifying the surface of wood, is accepted by the trade without question. Manufacturers and furniture dealers, through long experience, are thoroughly convinced that plywood construction is scientifically sound in principle and in fact. The householder considers durability of construction another strong factor to be considered in so important a matter as the purchase of a suite of furniture. Here again plywood construction has its strong appeal.

With many consumers, the old conception has already given place to the new, due to knowledge gained through intelligent study and observation. The prejudice, still harbored by a few consumers, may successfully be overcome by education—education of the buying public through the efforts of

intelligent and well-informed salesmen, and through making available to the public, textbooks and other sources of authentic information. The purchaser is a reasonable being, and once convinced, he decries the old and becomes an ardent advocate of the new.

That plywood actually makes possible a surface wood of superior grain and figure may be easily emphasized by making comparison between two tables of different construction. That of non-plywood construction is most likely to have a top made of several pieces of lumber, varying in character or figure, and perhaps in color and texture as well. The table of plywood construction exhibits a top of beautifully grained and perfectly matched figure and color, producing an artistic effect, possible only through the employment of the plywood principle. The demonstration, favorable to plywood, is made more convincing when the increase in strength is understood to be due to the laying at right angles of the various adjacent plies.

A praiseworthy tendency of the best policy in present-day salesmanship is the presentation of merchandise for exactly what it is. Many of the larger and better known furniture and department stores label their pieces openly and frankly. If the suite is made of walnut or mahogany, it is so marked. If the pieces are of gum or of birch, with a walnut or mahogany finish, it is so stated. If the construction is plywood, instead of attempting to deceive the prospective purchaser, as was formerly the indefensible practice of unscrupulous dealers, this fact—which is really a sales argument favorable both to the seller and to the buyer—is now plainly advertised and proudly proclaimed. The better stores forbid misrepresentation of any kind. They require the salesman to study his merchandise that he may know and truthfully explain the facts relative to the material at hand.

This acknowledgment of facts has done much to favor the general acceptance of veneers and of plywood. As the superiority in strength is explained and the uniformity of

matched figure and color are pointed out to a customer, the uninitiated comes to realize that the demand for "solid" pieces, as applied to furniture, is tantamount to a demand for that which by comparison, is inferior.

Furniture of the present day, even as in the Middle Ages, or as in the most effete periods of court luxury, conforms closely to social needs and conditions. Family requirements determine what a home shall contain. The massive style, admirable in the Italian palace or English manor house, is totally unsuited to the present mode of general living in America. Congestion in cities, with consequent high construction costs and prohibitive rents, has made imperative the necessity for economy in space. Furniture, in size, weight and shape, conforms to the reduced dimensions of the rooms where it is to serve.

In its convertible nature, too, furniture reflects its modern setting. A telephone stand, to be an ornamental part of a general room, conceals the instrument and perhaps serves as a desk or a table. A dressing-table, reminiscent of Sheraton, closes its top on rouge, lip-stick and powders and assumes the demure look of a magazine stand. A library table may house a complete kitchenette beneath its broad top. Breakfast sets, with tuck-away chairs, make adequate dining-rooms of tiny alcoves or sun-porches. Davenports that convert the living-room into a bedroom, are an accepted feature of small apartments. One English firm, specializing in this space-saving furniture, has evolved a piece which combines six in one—wardrobe, secrétaire, bookcase, deep drawer, cupboard with shelf, and folding-bed.

A visit to the furniture marts of various centers of manufacture or distribution in the United States, proves convincingly the adage that the American public is a single unit, as regards taste and usage. Walnut and mahogany are the predominating woods of the present mode. Both of these woods have long been used as veneers to emphasize the beauty of the

matched figure and the uniform color effects so readily obtainable in plywood construction. When other woods are employed, the finish applied is very likely to be the brown shades of walnut or mahogany, whether the wood is gum, maple or birch.

Next to the walnut and mahogany effects, the enameled, painted and stained suites seem to be most in demand, in the cottage type of furniture. For enameling, painting and staining, plywood is used for the sake of durability and smoothness of surface, and in the stained suite, particularly, the surface is selected for its figure, which is visible through the stain.

An innovation of a floral pattern in oils is the adornment of many pieces, where the plywood surface consists of plain veneers. In the higher priced lines, this work is done by the hand of an artist. In the less expensive suites, it is applied by means of decalcomania, a development of the simple transfer paper process of our childhood days. By one authority consulted, it is predicted that this prevalence of floral decoration is a forerunner of a popular return to marquetry. When marquetry now appears on some of the more expensive suites, it is imported from France or Germany, made up in flower or strip patterns of wood, all ready to inlay.

Designs of the present day cover a wide range, and no one style dominates the field for any length of time. Queen Anne reproductions were long popular, both in mahogany and walnut veneers. Italian Renaissance now appears in many of the suites designed for spacious, formal homes. Table tops, drawer-fronts, drawer-bottoms, doors and panels are veneered. For smaller places, Tudor is the designation which broadly covers everything of light walnut that makes any pretense of following early English design. Veneers, in a wide variety of matched patterns and colors are the chief decoration. "Early American" is enjoying quite a vogue and is made up in natural figured gum or maple in walnut and other finishes. These pieces are veneered. Spanish forms and finishes are

much in favor, perhaps because Spanish is the type of architecture extensively adopted in the rapidly growing colonies of Florida and California. Plywood construction is used in this, as in other forms.

Popular-priced furniture exhibits the strong desire for novelty and the shifting tastes of the masses. The newly acquired wealth of the great buying public has created a demand for furniture that has at least the earmarks of authentic style, with color and novelty added for variety. To satisfy this popular taste, all sorts of variations are applied to the prevailing mode. In the popular-priced lines, the concession is often made of combining motifs from several periods, "anything to fit the exigencies of the time and to satisfy the craving for novelty."

In furniture of the better grades, designs are based very largely on the masterpieces of the great cabinet-makers of the 18th Century in England. The general adoption of veneers and plywood as of that date will be recalled. Accurate reproductions are expected in the higher class of merchandise. Where considerable money is invested by people of conservative taste, one is apt to find selected a faithful copy of an old design.

Some of the more substantial and long established furniture houses find it a good investment to send their designers over to the fountain sources of art in furniture design. One Chicago firm had a man studying abroad for fourteen years. He is now recognized as a master of design and is invaluable to his company, whose clientele reveres the proven treasures of the past rather than the ephemeral novelties of the present.

The Paris Exposition of Modern Decorative Arts was a manifestation of the "Modernist" movement interpreted by European artists of 1925. Whether or not this dramatic coup shall regain for France her old leadership in the industrial arts, it does seem destined to influence in some degree, governing values and principles and to promote the designing of rooms and furniture which will synchronize with the tempo of modern

Illustration 37. Plywood effects in the library, designed by M. Dufrene and G. Englinger for the Paris Exposition of Modern Decorative Arts, 1925.

Courtesy, *The Architectural Record*

Illustration 38. Unique effects in the use of plywood in a lady's bedroom, designed by Dufrene and Tehernack, for the Paris Exposition of Modern Decorative Arts, 1925.

Courtesy, *The Architectural Record*.

life. Grotesqueries will disappear and essential elements remain. The project, before the designers, seemed to be to relate in proportion, contour and general style the furnishings to the architecture of the interior. The days of the Adam Brothers are recalled—when a room, to be considered complete, must have every appointment harmonious and motivated by the same theme.

Conspicuous in door-facings, wall-panellings, and even in ceilings, veneers of rare and beautiful woods were the decorative feature of many interiors. Furniture exhibited—whether for the library, dining-room or boudoir—testified to the universal acceptance of plywood construction. The elaborate, applied decoration of former decades has given way to a modern dependence upon richness of material and vivid coloring. Illustrations 37 and 38, photographs of some striking effects produced through veneering, taken from *The Architectural Record,* illustrate the observations of William Francklyn Paris, quoted from the September, 1925, issue:

> Modern designers utilize to its fullest value the texture of the woods which they employ. By sawing at difficult angles, they obtain an aspect of the grain which is novel and highly decorative. Much ingenuity is used in matching the veins, and often an accident in the texture caused by a knot is turned to advantage. . . . Quite frequently the wood is inlaid, sometimes with ivory, at other times with differing woods or even with marble and metal.
>
> No chair or table is set in its environment without its having been studied in relation to the walls, the hangings, and the other objects entering into the general decorative scheme. . . . The structural dimensions of the room are considered, the character of its occupant, the scale that must be preserved between the container and the contents, the color scheme and, if expressed, the preference of the client.

The assertion that furniture is designed primarily to meet social needs of the day is borne out by Mr. Paris in the following paragraph:

> The furniture of the last 200 years was eloquent of feminine graces, interpretive of more or less effeminate manner. . . . If a certain chair was in tune with the satin breeches and red-heeled slippers of our male ancestors, how can it be in tune today with our golf knickers and rubber-soled shoes? . . . The new style, while lacking in softness and languor, is yet rich in beauty and eloquent of poise and common sense.

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Thus, in concluding as it were, a review of furniture types, from their origin in ancient Egypt, on down to the ultra-modern, one is forcibly impressed by a similarity of treatment throughout the ages. In practically every epoch, striking examples are manifested in which some form of veneer is employed as embellishment and in which plywood serves as the enduring principle of construction.

# PART II

# VENEER AND PLYWOOD DEFINED

A variant in this use of veneer for curved surfaces, was the veneer facing of rectangular and curved edges of table tops and the like. Sometimes only the end wood of an edge was veneered to match the side wood, and at other times the entire edge of table top was veneered with grain vertical.

The economic aspect of using thin sheets of rare and beautiful figured veneers in order to secure the maximum surface of matched and uniformly patterned figure, instead of the utilization of full lumber thickness of rare woods, does not make its appearance until the middle of the 19th Century. Possibly in the older days when the labor costs were low, and the transportation of bulky materials extremely slow and expensive, the element of cost may have entered into the adoption of this practice. However, as labor costs have risen and the cost of transportation and of the cutting of lumber have been reduced by modern methods, it is apparent that most of the popular woods could be produced at lower cost if made solid instead of plywood construction. It is the superiority of plywood for beauty, durability and strength that has maintained its common use in better furniture and cabinet-work regardless of the additional cost.

About this time, manufacturers began to appreciate the possibilities of the commercial use of several sheets of veneer formed into curved shapes. This purely utilitarian use of bent wood was entirely independent of the artistic value of concealing essential but unattractive structural features in furniture, as suggested above. (See Illustrations 47, 48, 49, pages 129, 130, 132.)

The scientific value of cross laminations and layers of many thin sheets glued together, and the appreciation of the increment of strength due to such construction, does not appear to have much recognition until nearly the beginning of the 20th Century. Thus it becomes clear that from a limited beginning as an exclusively artistic material, veneer has grown to have many important industrial uses.

## The Origin of the Word "Veneer"

Proceeding now from the historical development, it is found that derivation of the word is from the German "furniren," old French "furnir," modern French "fournir," to furnish or to finish. Some references in older books still allude to "fenere," showing an intermediate form of spelling. Evidently at the time the word "veneer" came into use it was associated with the idea of a finish, or a decorative effect. At that time there seems to have been no idea or vision of the broader applications of strength, economy, balance and the wider ranges of use outlined above.

The current dictionary definitions of the word seem also to confirm the above limited application. Webster (Unabridged—1919) gives:

> *Noun:* (1) A thin leaf or layer of a more valuable or beautiful material for overlaying an inferior one, especially such a thin leaf of wood to be glued to a cheaper wood.
>
> (2) Superficial or meretricious show.
>
> *Verb:* To overlay, or plate, as a common sort of wood, with a thin layer of finer wood for outer finish or decoration: as to *veneer* furniture with mahogany. "As a rogue in grain *Veneered* with sanctimonious theory." (Tennyson)

The Century Dictionary (1893) follows closely the same thought, also using the same quotation from Tennyson:

> *Noun:* A thin piece of wood of a choice kind laid upon another of a more common sort, so as to give a superior and more valuable appearance to the article so treated, as a piece of furniture.
>
> *Verb:* To overlay, or face, as an inferior wood, with wood of a finer or more beautiful kind, so as to give the whole the appearance of being made of the more valuable material.

The Standard Dictionary (Funk & Wagnalls—1925) covers approximately the same ground, viz:

*Noun:* A thin layer of rare or beautiful material, as wood, stone, ivory, or mother-of-pearl, fastened upon a commoner surface to produce a rich or artistic effect.

*Verb:* To cover a surface with veneers, especially rare or beautiful woods.

There is perhaps an inference and intimation in the above definitions that the quality of veneered goods is somewhat superficial and that they are not made of good material throughout. But final judgment should be withheld until the modern uses are fully described, in subsequent chapters, and the breadth of modern applications is recognized and appreciated. It will be discovered that veneer has outgrown its earlier uses, and now occupies a place in the commercial as well as in the artistic world where it commands greater public esteem and deserves a different interpretation than in the past.

## In the Realm of Fiction

It is a curious commentary upon our American system of education and thought that there should have developed in the public mind such a wide spread erroneous prejudice against veneer and veneered products, especially in the making of furniture.

Charles Dickens, in "Our Mutual Friend," held up to ridicule the "Veneering" family. There are at least two novels, "The Veneerings"[1] and "The Veneered Savage,"[2] both of which emphasize and make conspicuous the superficial and camouflaging interpretation of the term veneer. And it is possibly from the novelistic origin that our imaginative intelligence derived the notion that the very word veneer was suggestive of the superficial and pretentious rather than the bona fide and true. Hence, we often hear the compromising comments, "a veneer of good manners," "a veneer of respectability" or "a

[1] "The Veneerings," by Sir Harry Hamilton Johnston. Published by Macmillan, New York, 1922.

[2] "The Veneered Savage," by Grace L. Furniss. Published by Harper Bros., New York, 1891.

veneer of good looks." However, facts do not seem to support this peculiar prejudice, and such revealing facts, clearly and frankly placed before the public, will do much to dispel this illusion.

## Modern Reasons Favoring the Use of Veneers

In spite of the somewhat doubtful and compromising character given in the definitions of the word "veneer," and its rather sinister meaning in the popular interpretation of the word, it must be perfectly clear that the use of veneer has survived the centuries and that the arguments for the modern utilization of veneer are decidedly cumulative, dating, as they do, from antiquity, coming down through the history of furniture making, and resulting in a rather complete defense of the use of veneer from several points of view.

It is no doubt true, that zeal, unwisely manifested, has carried some manufacturers too far in the use of veneer, where solid wood would have been more serviceable. Experience seems to prove conclusively that in some places the use of veneered stock is correct, in other places, it would be foolish, and in a rather wide range of border line problems, its use may be considered optional and within the discretion of the manufacturer. It may also be observed that there are many places in which solid wood cannot be advantageously used, and where veneered stock is much superior.

## Suitability of Material

The purchasing power of the American people, so far as home furnishings and equipment are concerned, is largely concentrated in the wife and mother. That she has shown wonderful competency in making our homes artistic, comfortable and livable, is beyond argument. In most of her purchases she shows discretion and shrewdness and there is no doubt but what her buying of furniture would be more intel-

ligent if she really appreciated the proper use of veneer and knew how well it does express beauty, strength and durability. The traditions and prejudices against veneer will be overcome as rapidly as the facts are brought to her attention in a forceful manner.

Take the question of a new table, towards the purchase of which the family funds have been budgeted for some months. A "solid" mahogany table seems to be an expression of genuineness and worth, like a solid silver spoon or a solid gold watch. A "veneered" top on a table calls to mind plated silverware or time-pieces. As a matter of fact, the silver spoon is more serviceable, and no less desirable, when it contains a substantial amount of metallic alloy to add strength and durability. Likewise, a watch with a gold filled case (a substantial layer, or veneer, of gold on a stiffer and better protective metal beneath) is lighter and stronger than a solid gold case. Obviously, the working parts of a watch must be made of steel, brass or other alloy, with hardened or jeweled bearings. A watch with solid gold works would be the height of folly. And yet is a "sterling" silver spoon, or a high grade gold watch (a large portion of which is not gold at all) considered less than the best?

Why should not the same considerations of suitability govern the furniture field, in the use of veneers, for face woods, and in the employment of stronger and less expensive base wood, or core where strength is required and where the use of the less expensive wood in nowise detracts from genuineness and durability?

The advantages of veneered construction will be more fully outlined and supported by ample evidence in the next chapters under the head of "Plywood."

## Salesmanship

The furniture salesman of today certainly requires an extraordinary range of versatility, to handle milady, his best

customer, in a skilful and competent manner. In addition he must keep abreast of all the modern types and styles of construction, as well as the character of the designs and finishes utilized by furniture manufacturers, in order to coax dollars from the purses of the purchasing public.

The efficient salesman of today must rise above the misinformed or uninformed salesman of yesterday, who had little chance to learn the truth about veneer and plywood. Manufacturers apparently did not then emphasize nor explain the value of veneer, and salesmen were under the necessity of selling the manufacturers' products to consumers who vigorously (although mistakenly) demanded "solid" goods. A paradoxical situation in which the easiest course was usually followed, and truth and frankness sacrificed.

One of the primary purposes of this book is to inform buyers and sellers alike, of the underlying facts regarding the use of veneers in furniture and like products, a subject from which subterfuge and misrepresentation should be banished.

Veneered stock, when rightly made and thoroughly understood, will rise or fall on its intrinsic merit alone. Truth cannot hurt, and misrepresentation will vanish when facts are frankly recognized.

Misrepresentation deserves no place in genuine salesmanship. True definitions and correct descriptions lead to mutual confidence and fair dealing. The salesman who states that a certain table is "solid" walnut, either when he does not know, or knows it is not, deserves no consideration in the present age of enlightenment.

The well informed salesman will help to educate his customers along intelligent lines of thought, and explain more adequately the proven facts regarding the use of veneer. Tradition, sentiment, prejudice and ignorance should be outgrown and discarded.

# CHAPTER XII

## THE SUPERIORITY OF PLYWOOD

### Plywood Defined

The practical use of veneers of wood involves the gluing together, either of several layers of veneer, or the gluing of one or more layers of veneer to a foundation or core of lumber or other material.

*Plywood,* being a new term and unrecognized by the dictionaries and encyclopedias, has not as yet acquired a generally accepted meaning.

As popularly used by most woodworkers, it refers to more than one layer of wood (lumber or veneer) glued together over the whole of the adjacent surfaces. The rather disparaging, popular conception of the term "veneer" or "veneered" led the manufacturers and users of veneered stock, whether all veneer, or all lumber, or a combination of lumber and veneer, to search for a comprehensive term that would be descriptive, practicable and useful. Hence the formation of the Plywood Manufacturers' Association in 1919, consisting of the leaders in the working of veneers into glued-up stock.

The Forest Products Laboratory, maintained by the United States Government at Madison, Wisconsin, has attempted to draw rather close technical limits on the various kinds of veneered products:

> *Laminated wood,* refers to constructions in which two or more layers of wood are fastened together with the grain of all plies or laminations parallel.
>
> *Cross-banded veneered panels,* refers to glued material with vener faces, veneer cross-bands and a lumber center or core.
>
> *Plywood* is used to describe a combination of several plies

or pieces of veneer glued together usually so that the grain of any one ply is at right angles to the adjacent ply or plies.

Since this technical grouping leaves a wide border zone between the two latter groups and since the term cross-banded veneered panels is at variance with common usage and too clumsy for convenience, the term plywood will be used throughout this book as a general term to include all three groups, except laminated lumber. Several of the border zone cases are:

*3-ply* with rotary veneer or lumber core.

*5-ply* with thin veneer face and back using 3-ply rotary veneer construction as a core.

*Legs,* posts or feet for tables, desks, pianos, cabinets, etc., constructed of two or more thicknesses of solid lumber, glued together for the purpose of greater strength with correspondingly less tendency to warp, twist and check under finish.

*Grand piano rims* consisting of several layers of veneer with parallel grain, etc.

The present trade designations are no clearer than the technical group above:

*Panels,* referring particularly to 3-ply veneer construction, in which face, back and core are all veneer. This also includes 5-ply, when all layers are of veneer.

*Tops,* a term coming from the use of 5-ply, with lumber core, for table, bureau, commode, desk and counter tops, and is quite generally so understood. It is also used in referring to tops of 3-ply construction.

The objections to this division are that there is still a border zone between the groups, where one manufacturer might choose a lumber core and another a veneer core, both producing the same eventual thickness of plywood. Top construction might be used for a foot-board of a bed, a cabinet door, a bureau-end, or a drawer-front. The word panels is too general, as it may apply to metal, stone or composition units, and as it is also used for electrical panels, type-set panels, etc.

It is felt by the authors that the comprehensive use of the

word plywood is for the best public interest, and will clarify rather than confuse the issue. Subdivisions of the various kinds of plywood will gradually develop as the industry expands and enlarges.

During the preparation and publishing of this volume, the Plywood Manufacturers' Association has been active in supplying this definition and the following has practically been adopted for the next edition of one of the leading dictionaries:

> Plywood, *n.* 1 plywud; 2 plywood, A compound wood with surfaces of *veneer,* usually built up in odd multiple plies of 3, 5, 7, 9, etc., the various plies being glued or cemented together under pressure. (See veneer press.)
>
> Properly glued or cemented plywood joints are many times stronger and more resistant to stress and strain than is the fibre of solid wood.—(See tables of U. S. Forest Products Laboratory, Madison, Wis.)
>
> Plywood Standard 3-ply construction, the two outer layers or plies lie parallel, the inner layer or core being placed at right angle to the outer plies.
>
> Plywood Standard 5-ply construction, the two outer plies and the core or middle ply lie parallel while the two additional plies, termed cross-bands or cross-binders, are placed at right angle to the other three plies and parallel with each other; one cross-band being placed between the face ply and the core and the other placed between the back ply and the core. This construction is used to give strength, rigidity and balance, thus preventing warping, splitting or twisting of the finished plywood.
>
> Standard plywood is used chiefly for the manufacture of household and office furniture, for piano cases, phonograph and radio cabinets, for paneling in interior decoration, etc.
>
> Bent or shaped plywood—used principally for chair and opera seats, bow-end beds, shaped drawer and cabinet fronts, tops and ends, sewing-machine cabinet tops, etc.
>
> Package plywood—used for merchandise packing and shipping cases, for shipping containers for metal or glass cans, jars, etc.
>
> Waterproof plywood—is made using waterproof albumin glues; plywood may be made waterproof to the extent

that hours of soaking and even boiling in water will not separate the glued plywood joints. Waterproofed plywood is extensively used in the manufacture of airplanes, refrigerators, automobile disc wheels, automobile coach bodies, outside door panels, stiles, rails, and wherever a plywood product resistant to moisture is required.

## Advantages of Plywood

There are six fundamental reasons favoring the use of plywood. The first four reasons refer largely to cabinet work, where veneer is used flat, and these are grouped together in one chapter. The curved uses and engineering applications are so different that each is treated in a separate chapter.

*First:* Figured veneer is usually cut across the grain, and is, therefore, fragile and needs a supporting foundation, or base, of a tougher and stronger wood.

*Second:* Irregular figure in veneer always requires balancing and matching for symmetrical and artistic results.

*Third:* Conservation demands that figured woods of substantial value should be used chiefly for artistic results and that the less valuable woods be used for purposes of strength.

*Fourth:* Unbalanced internal stresses in solid wood can be equalized and maintained in balance by properly applied veneer of two or more equal layers, either figured or plain.

*Fifth:* Curved, regular and irregular shapes, such as opera seats, grand piano rims, bow-end beds, etc., can be formed using thin sheets of veneer pressed and glued together in forms to produce the particular shape desired.

*Sixth:* The strength of wood increases greatly when multiple layers are glued together, particularly when laid at right angles one to the other, i.e., a 5-ply piece of veneered wood, built up of five layers each of 1/20 inch thickness is stronger than a piece of ordinary lumber 1 inch thick.

The nearest approach to the above outline that has been discovered in reference literature is found in the Encyclopedia Americana, under the head, "Veneers and Veneering":

To the average man today, the term "veneers" means to cover up cheap and shoddy work, or to make a whitewood cabinet or other piece of furniture look like a mahogany one. From this false conception has arisen the idea that all veneering is bad work. It must be admitted that bad work is done, and it is in consequence all the more difficult to convince the public that veneered work, when properly done, and shows that it is plywood, is the best and most effective work for the following reasons:

1. It is the only way to use the rare woods, such as "crotch" in satinwood and mahogany, "burls" in amboyna or walnut, and crossgrained but pretty work which would only twist if used in the solid;

2. The layer of veneer tends to strengthen and preserve the wood on which it is laid;

3. Veneering gives the only opportunity for flat decoration in furniture, by using the grain of the wood for designs in panels and on wide surfaces;

4. The process needs more care and thought in the selection of wood, its preparation, application and finish, than is required in ordinary solid work.

## Why Glue Holds Wood Together

Glue makes the strongest joint known between two pieces of wood, whether the pieces are sheets of veneer, or boards, or blocks. Glue (except special water resistant varieties) and wood are both unfavorably affected by moisture. Therefore, any well made piece of furniture should have its surfaces protected by some coating or finish, such as varnish, enamel, lacquer or paint. Even the under-side of a table top or the back side of a cabinet door, and any raw edge should be coated with some preparation that will effectively retard moisture changes. Any of the above finishes will do this, or shellac will serve the purpose. Solid wood and plywood should both be so finished, with all exposed pores filled, on both surfaces and all edges.

For comparison, it may be assumed that two table tops, one of plywood (5-ply), and one of solid wood, have been insufficiently finished, with the under-side entirely unfinished and

the edges improperly filled. These tops, or the piece of furniture of which they are a part, are stored in a damp warehouse. What may be expected to happen to each?

The underfinished ends of the solid top, as well as the similarly raw ends of the plywood top will absorb atmospheric moisture and endeavor to expand. The under-side of the two tops will absorb likewise. The solid top will have no resistance to offer to these expansion stresses, and will eventually warp and curl, and probably check. Glued joints will open up and wood tear away from the glue under so great a stress and so narrow a surface of glue.

The plywood top, however, has four strata, or layers of glue, one strata within 1/16 inch or less of each surface, and atmospheric moisture will not so easily penetrate these combined wood and glue strata. The expansion stress in 1/16 veneer (produced by surface moisture absorption), will be abundantly counterbalanced by the remaining 3/4 inch of relatively protected lumber and will be practically impotent. The moisture absorbed by the ends of the core wood will produce expansion stresses, but two strata of glue and two sheets of veneer above and two of each below (notice the large glue area of the surface compared with the area of the edge in the solid top), will again counterbalance the expansion stress.

Will atmospheric moisture at ordinary temperatures weaken the ordinary glue joints between the veneer? This is just possible, but in many years of observation no such case is known to have occurred. Well set glue that has made a tight joint will tear the wood before it will let go. In other words, a properly made glue joint is much stronger than the wood.

If the plywood top is immersed in water, or placed where water can be drawn into it by capillary action, or left exposed to the weather, the glue joints will open, of course, and the veneer will become loose. Under like conditions, however, a solid top will absorb just as much, or more, moisture in the form of water, and will be as badly wrecked as the plywood.

# CHAPTER XIII

## ADVANTAGES OF PLYWOOD EXPLAINED

### Fragility of Veneer

Many of the most beautiful figures in wood are caused by cutting across the twisted, wavy, curly, irregular or otherwise distorted fibres formed by a butt, stump, root, crotch, burl, or some other abnormality, as graphically shown in Illustration 39. Solid wood, one or two inches thick, from such locations in the tree, would warp, curl and check, under manufacturing

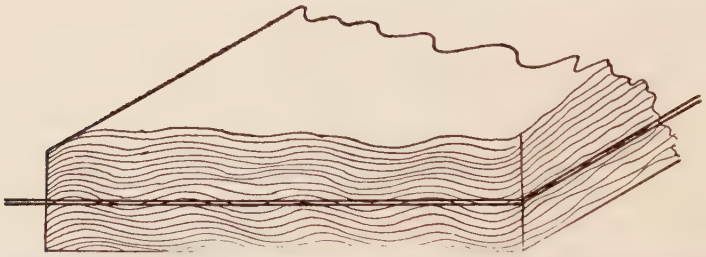

Illustration 39. Showing how a cut straight across a section of wood with a curly grain will show a wavy figure. Most other figures similarly caused.

and service conditions, to such an extent as to ruin in a short time the resulting piece of furniture.

Much of the figure is caused by end or slanting grain, which in solid wood, rarely takes an even color nor readily acquires a smooth polish, since end grain is more porous, absorbing more stain, and will not work down into a surface as attractive and durable as side grain. Thin sheets cut into veneer from such end grain wood are fragile and easily broken; in fact, they should be stored and manufactured in a partly moist condition to avoid damage in handling. When carefully cut or sliced into thin sheets and glued to a core, this tendency to distort can be counteracted and overcome.

The stripe or "ribbon" effect in mahogany is a manifestation of the softer and more feathery portion, alternating with the plainer and harder portions between the stripes, and is correspondingly more difficult to finish. The stripe or "streak" in walnut and gum respectively, is either a growth ring or growth effect from localized pigment. Mottles and "fiddlebacks" are still other indications of wavy grain, and the cause of "bird's eyes" in maple apparently still remains undiscovered.

## The Core as a Foundation

The designer and manufacturer who would obtain the most desirable effects from nature's choicest growths of figured wood is obliged, because of practical considerations, to utilize thin sheets of the highly figured stock and mount them on a base of dependable wood that will hold its shape under the vicissitudes of changing climates and hard use, if not under actual abuse. A solid base under a figured sheet (end grain partially exposed) becomes a reinforcement to the fragile veneer and permits the satisfactory finish and polish that is so necessary to high grade results.

These bases are called cores, or centers, and may be of veneer, lumber or even of other material of similar character. Frequently, as in 5-ply, a sheet of plain veneer is interposed between figured face veneer and core; this is called a cross-band, or crossing, since its grain is normally crosswise, or at right angles, to prevailing grain of face veneer and core. Face veneer and core customarily have parallel grain.

## Balanced and Symmetrical Effects

Nature usually produces wood figure in irregular shapes and random effects, and only in a few instances, such as curly, bird's-eye and stripe woods, can the natural figure be used "as is." In fact, a flitch (complete bundle of thin sheets laid together in sequence as they are sliced or sawn) of figured

wood usually appears to the uninitiated most unattractive and lacking in artistic possibilities. When used singly, without matching, the result is likely to be grotesque. Sloping, slanting

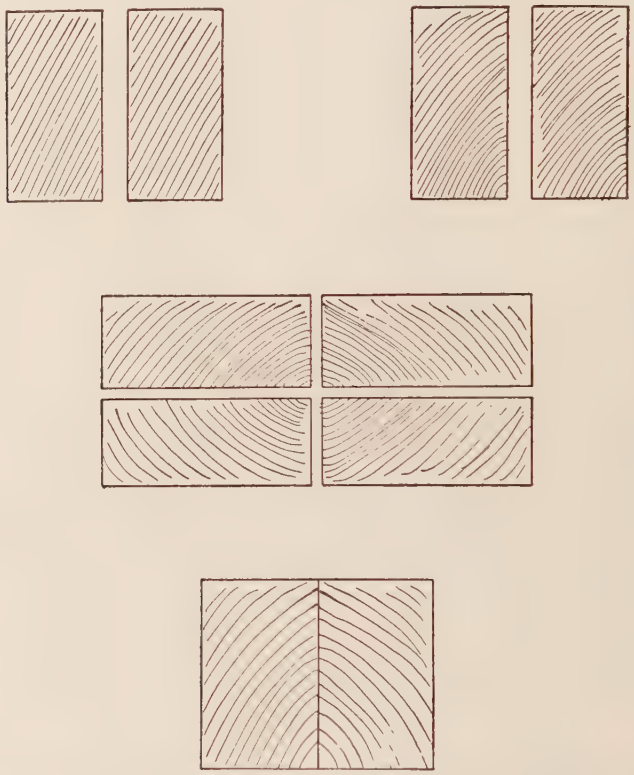

Illustration 40. Showing optical illusions produced by angling figure, which often make objects look out of square, etc. Center sketch shows how figure can be matched, and lower sketch shows balanced matching.

or "off center" figure, when used alone, will often produce an optical illusion of being "out of square," irregular or otherwise indicative of careless craftsmanship. (See Illustration 40.) Two adjacent sheets will have practically the same pattern, and if one is reversed and the two laid edge to edge it will give a matched or balanced appearance that will enhance

Illustration 41. Showing two-piece black walnut, center-matched, producing symmetry and balance out of angling grain character in the veneer.

Courtesy, Pickell Walnut & Veneer Co.

the beauty of the single piece and often turn the distorted pattern into an artistic result, as shown in Illustration 41.

In the case of quarter sawn oak, the strips are usually narrow, and often two, four, or six strips are needed to make the required widths. Every other strip is reversed and the result is two or three pairs of matched pieces, arranged in series. A little methodical planning will produce balanced results, whether with large "splash" oak figure or modest "herringbone" pattern. Other woods with pronounced stripe are sometimes combined into angling or "zebra" patterns. (See Illustration 86 *a*.)

The side matching is done by planing or "jointing" the edges of the veneer strips, and fastening the neighboring pieces together by means of gummed cloth or paper (which is removed after the assembled sheets are glued to their base or core), leaving a joint that is perceptible only as a change of direction in the grain of the wood.

In addition to the side matching we have a further development in end matching, where two or four adjacent sheets of veneer, having the same pattern, or figure, are jointed and taped together at their ends (or at both ends and sides) so as to produce desirable and artistic effects which are amazing, as shown graphically in Illustration 43. Sheets of highly figured stump or crotch veneer in the hands of an expert, can be transformed into curious and wonderful designs. Four-piece butt match effect is always popular and is most frequently found in plywood used for furniture, pianos, phonographs, radios and interior panelling.

It must be apparent that adjacent boards of commercial thicknesses would not have sufficiently similar figure to permit the matched and balanced patterns described.

## Mitered and Segmental Arrangements, Inlays and Marquetry

The use of figured woods in segmental arrangements, borders, decorations, inlays or appliqués is conspicuously the vogue

in plywood workmanship and the variations and combinations are too numerous to describe here. Suffice it to say that the ramifications of assembling similar and contrasting woods lead into marquetry, parquetry and inlaid work, where various colors and shades of figured woods are combined for border, medallion, corner and diamond pattern work.

It must be obvious to the reader that only veneers, and never solid woods, lend themselves to such a wide variety of combinations.

## Economic Utilization

Relative Cost of Veneered and Solid Tops. It is popularly supposed that a veneered or plywood table top with a veneer face is cheaper than and inferior in quality to solid wood. An analysis of costs will clarify this situation.

In order to understand this matter, it is necessary to realize that the best quality of logs invariably are cut into veneer, and that the poorest are sawed into lumber. The price of lumber from a veneer grade log would be prohibitive, and no one would take, as a gift, the veneer produced from a log suitable only for lumber. An example may make this clearer: sheets of veneer 1/24 inch thick and at 2 cents per square foot represent a fair market price. The equivalent value of lumber would be 48 cents per square foot, but it takes 1-1/8 inches of log to allow for the shrinkage and saw kerf necessary to produce a board 1 inch thick, which increases this equivalent value to 54. This means $540 per 1,000 feet of lumber, and is obviously prohibitive. As a matter of fact, a 2-cent veneer market about corresponds to a $200 per 1,000 feet lumber market, considering the normal market classification into logs suitable for veneer and lumber.

If a dollar were to be spent for plywood tops of standard grade, and another dollar for solid tops of as nearly a similar grade as possible, how would the two dollars be analyzed? It

Illustration 42. Showing quarter sawed oak, three-piece matched. Alternate strips turned like leaves of a book to give balanced figure.

Courtesy, New Albany Veneering Co.

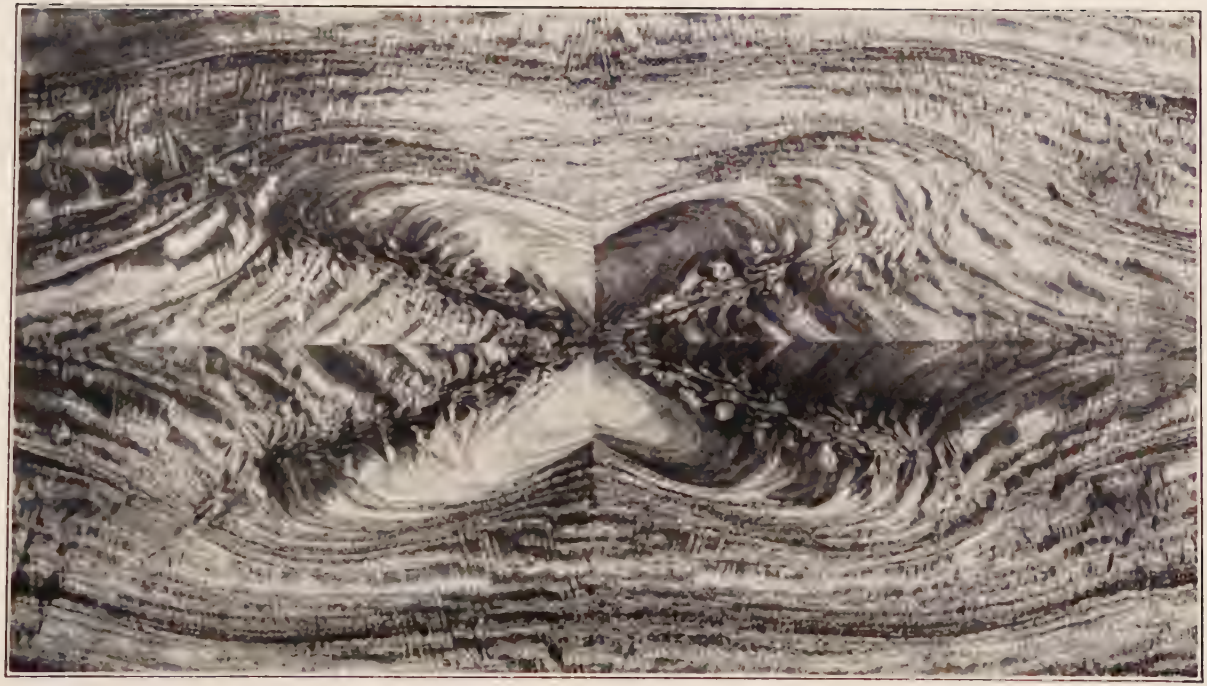

Illustration 43 Four-piece, end- and side-matched, crotch mahogany veneer, showing some mottle and cross figure in the outer edges of the veneer.

Courtesy, Harris-Ward Veneer Co.

would be found that each dollar would purchase practically the same amount of superficial area of tops, but the division into labor and material would show marked variation. The figure of the veneered top would be greatly superior to that of the solid top, yet both would be genuine.

The diagrams shown in Illustration 44 indicate the component parts of the two dollars, the dollar of the solid top

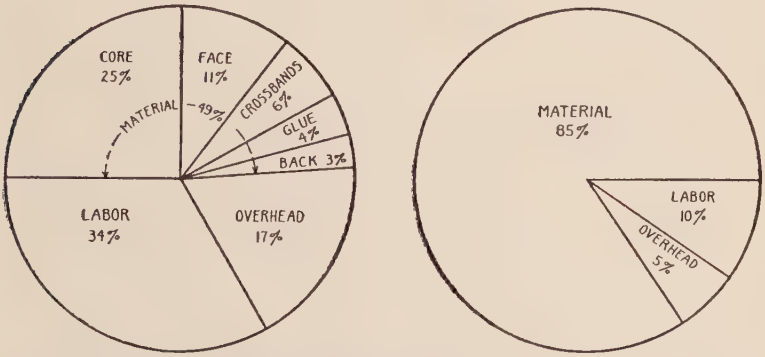


Illustration 44. Showing relative value of material and labor cost in plywood tops (left) and solid lumber top (right).

showing a large proportion for valuable material and relatively little for labor, while the dollar of the plywood top shows clearly the result of lower material costs, but of considerably greater expenditure for skilled labor in fabrication. Since this fabrication means a better arrangement of wood for balancing internal stresses and strains, as well as for the utilization of face veneer, it seems abundantly to justify its cost. What is saved in material is, therefore, expended in workmanship. The result is better structurally and possesses a more highly figured surface.

A reasonable comparison is the use of a surface of cut stone, terra cotta, or face brick in a building. It is never granite or face brick all the way through. Steel, concrete, hollow tile and other elements of strength and lightness make better

construction. Neither the Washington Monument nor the Equitable Building are solid granite!

Comparisons of Quantity. A relatively small number of tops may be made economically from the lumber, produced from one particular log, while the veneer produced from a similar log is sufficient to cover the surface of enough plywood to make several hundred tops of similar size.

If a beautiful piece of wood is available, from which 1/24 inch veneer can be sliced, is there any reasonable excuse for sawing it into boards, each board consuming twenty-seven times as much bulk of the wood (1-1/8 inch) as the veneer? Why not grace twenty-seven homes with a beautiful table top, rather than only one?

To accept this conclusion, however, it must be proved that a plywood top is at least as serviceable or more so than the solid top. This it is purposed to do.

## Balanced Internal Stresses

Every piece of wood normally will shrink and swell under varying conditions of treatment, in different climatic surroundings, and according to its actual moisture content.

The most universal manifestation of this fact is the manner in which doors and windows (if of solid construction) used in our homes and offices, react under changing climatic conditions. In humid spring and fall weather (when there is little or no artificial heat) they are snug and tight, sometimes to an annoying degree. In dry summer weather, or under the influence of artificial heat, these identical doors and windows will be loose in their respective openings, will often admit gusts of wind and produce unpleasant drafts and will rattle most noticeably.

It is worthy of note that flush surfaced doors, made of plywood, do not appreciably change in size with the seasonal conditions, and in this regard differ from solid doors.

The possible amount of shrinkage between green and dry wood of the more common species is considerable, and is shown in the following table: (Averages are shown only.)

| Wood | Original Moisture Content When Green | Per Cent Shrinkage from Green to Dry | Width Inches Lost by Shrinkage Width in One Foot |
|---|---|---|---|
| Ash, white | 40% | 5% | .6 inches |
| Basswood | 100 | 7 | .84 |
| Birch, yellow | 65 | 8 | .96 |
| Fir, Douglas | 42 | 6 | .72 |
| Gum, red | 71 | 9 | 1.08 |
| Hemlock | 34 | 4 | .48 |
| Maple, hard | 62 | 8 | .96 |
| Oak, red | 57 | 8 | .96 |
| Oak, white | 60 | 9 | 1.08 |
| Pine, white | 36 | 5 | .60 |
| Pine, yellow | 50 | 8 | .96 |
| Spruce | 35 | 6 | .72 |

Permanency of size and shape is the principal reason underlying the proper drying of all wood products. Wood is, however, decidedly hygroscopic and porous, and its surface readily absorbs or evaporates moisture, which moisture transfusion is accompanied by at least a tendency to swell and shrink. If all of the pores or openings of a piece of wood could be sealed or otherwise filled against absorption, we could hope to achieve an unchanging and unchangeable size and shape in a wood object, but this is not practicable.

Lumber, when kiln dried and suitable for cabinet work, is porous and easily affected by moisture or heat, or both. If two boards are laid side by side on the ground in the sun for a few days, the edges will warp, i.e., the under-side, absorbing moisture from the ground, becomes wider than the upper side, kept dry by the sun, as graphically shown in Illustration 45; and if the two boards are both turned over, a few days more exposure to the sun will reverse the moisture conditions in the boards, and cause the edges to warp back to normal and beyond with edges curled up in opposite directions. This is

an exaggerated example of what may happen to a solid table top, made of two boards, varnished on upper side and unfinished underneath, where it may be exposed to damp atmospheric conditions. Normal, unexaggerated stresses show the

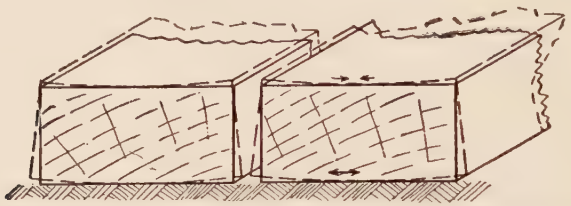

Illustration 45. Showing unbalanced stresses, where boards have upper side protected from moisture absorption, while under side is free to absorb. Conditions and proportions greatly exaggerated to indicate graphically stresses which are equally operative, even when less observable.

same tendency. In other words, boards have internal strains and stresses which may be easily unbalanced, and when out of balance will cause warp, wind, or twist; if the adhesion of the minute fibres is strained to the point of separation, the result is checking. A board well-dried and prepared for manufacturing, will stay flat only so long as the stresses are maintained in balance. The problem, therefore, is to keep the internal stresses permanently balanced. In solid wood this is difficult, if not impossible, and nearly all antique solid furniture shows seriously warped parts, with corresponding open joints.

One of the chief reasons for gluing up plywood, consisting of several layers of veneer or lumber, is to secure this permanent internal balance. Illustration 46 shows the different layers, separated so that the reader can more easily visualize the construction of a 5-ply top using a lumber core, and a 3-ply panel using a thick veneer core. The grain of the face and back veneers of the 5-ply are both parallel with the grain of the core, and the intermediate crossings have their grain at right angles thereto. When this piece of plywood is assembled, or laid up, pressed together with glue into a solid mass, and so

dried, the result will be a rigid unit of the whole in which the right angle grain of the crossings and the four glue layers produce a permanent "set" or balanced condition of internal strains and stresses. A similar balanced result is achieved in the 3-ply, where the veneer core alone furnishes the right angle stabilizing effect.

The face veneer in 5-ply is usually from 1/32 to 1/16 inch thick, backed up by a cross veneer (that can be hard,

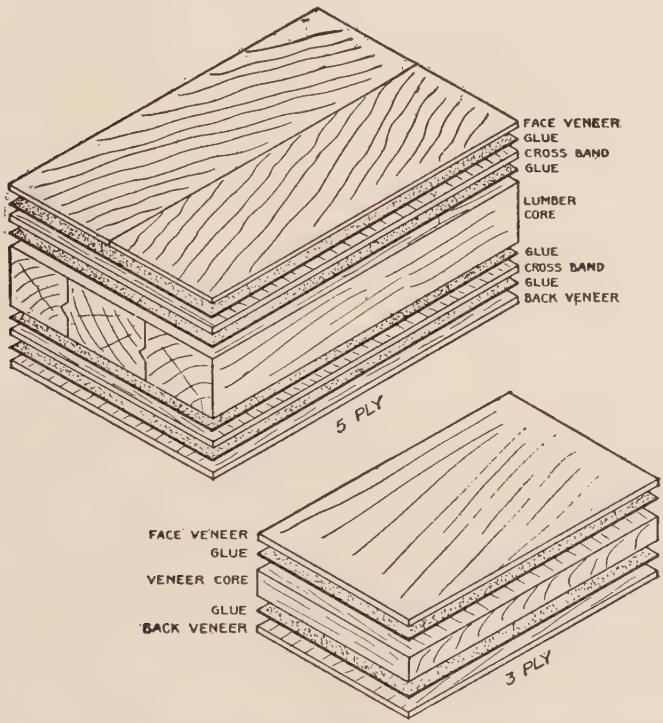


Illustration 46. Showing construction of 5-ply and of 3-ply, the strata being separated to indicate structural features, and giving an idea of how internal stresses in all strata are equalized.

close-grained wood to reinforce a soft or fragile face); and the face and crossing glued to a core of suitable lumber that is strong, holds glue, and does not readily distort, such as chest-

nut or poplar. The resistance to distortion rests chiefly in the core, and the protective layers on both sides. The back veneer and crossing must be of the same strength, thickness and quality as the corresponding face items, so as to equalize the stresses and strains and create a perfect balance. The entire five plies may be glued together at one operation.

In 3-ply, the face veneers are usually only slightly figured (core defects or irregularities might show through thin face wood unless cross-banding were interposed) and may be of any desired thickness, while the core is usually of a heavier veneer and there are only two layers of glue. Faces and backs should be of equal thickness and the entire gluing done in one operation.

When properly filled, stained and finished, well-built plywood will be "in balance" and always stay flat, will resist atmospheric changes much better than solid wood, will be equally strong in all directions (i. e., cannot split) and will give a permanence to furniture that cannot be assured in solid wood.

## Veneered Edges

The design and finish of many pieces of furniture can be improved by covering exposed end and edge wood with veneer. To avoid the dark and characterless effects of the ordinary finishes on the ends and sides of table tops, a strip of veneer glued on each end and edge permits a uniform finish on all four edges. If the table tops are of the round or oval shape, the edge veneer can be carried entirely around in one piece.

Sometimes an edge veneer, with horizontal direction of grain is not satisfactory. The application of an edge veneer with vertical grain is not quite so easy, but in certain instances is well worth the extra cost. (See Illustration 23, page 69.)

A similar use is on the fronts of bureaus and cases, where it is advantageous to have rails or separator strips, between

drawers or doors, faced with a vertical grain veneer. The part to which this veneer is glued must obviously be designed for strength and usually has horizontal grain. A similar effect may be frequently noted on the front of arms and feet of an upright piano case.

# CHAPTER XIV

## CURVED SHAPES, A UTILITARIAN VENEERED PRODUCT

Thin sheets of veneer are pliable enough to bend around many curved and irregular shapes. Veneer so applied will often serve to cover up joints and other structural features that would otherwise impair the beauty of a design.

Three, five, or more sheets of thin veneer may be glued and pressed together in a form or mould, producing, when dried, plywood with a permanent "set" or shape.

### Cabinet Work

The "swelled front" on bureaus or vanity drawers is an instance of the use of veneer to cover curved surfaces made of built-up, jointed and shaped lumber. Sideboard cupboard doors are frequently so made. The sides of phonograph cases are sometimes convex, requiring veneered surfaces. Interior drawer-fronts in writing desks are sometimes veneered on a concave surface, and pigeonhole doors are occasionally concave veneered. Rounded end sewing-cabinets and kidney shaped desks require extensive use of such curved exterior veneer. (See Napoleon's desk, Illustration 16, page 54.) Beds of some styles have "rolled" head and foot boards and others, "bow" ends.

Table pedestals of columnar form, particularly in the single pedestal extension dining-room tables, are veneered. Solid pedestals were found too heavy, and the clamping together of many strips to make a hollow column always left exposed glue joints which had to be covered by veneer.

Curved legs and arms of davenports and large chairs were usually laminated of several thicknesses of 1-inch lumber. The varying end and side grain exposure when such shapes were band sawed, was not attractive and was usually veneered over.

And this is by no means the whole of the list of such applications of veneer to furniture.

## Shaped Seating

Pews, settees, and individual opera chairs are usually made of three to five plies of veneer. The making of "male and female" forms for such curved work is quite an art, since it is

Illustration 47. Showing 5-ply, all-veneer opera seat, with face core and back grain from rear to front and crossings at right angles thereto.

desirable to shape as many units as possible at one gluing, and it is absolutely necessary that all portions of the curved surfaces be under approximately equal pressure during the setting of the glue. Only in this way can a uniform "set" be obtained without loose glue joints or irregular shapes.

The individual seat portion of an opera chair has a reverse curve, sloping up at the rear to accommodate the back and curving under in front to fit the knees, as shown in Illustration 47. The back of such a seat is usually a simple curve to fit the body, supported at both edges by adjacent seats.

Plywood is often used for school desks, recitation room writing-arm chairs, auditorium seats, portable folding chairs, and the like.

Church pews are by no means always made of veneer, but a more comfortable seat and back are secured if the curves conform to the human figure.

Railroad station and waiting-room settees are usually made in one continuous curved piece of plywood, shaped to accom-

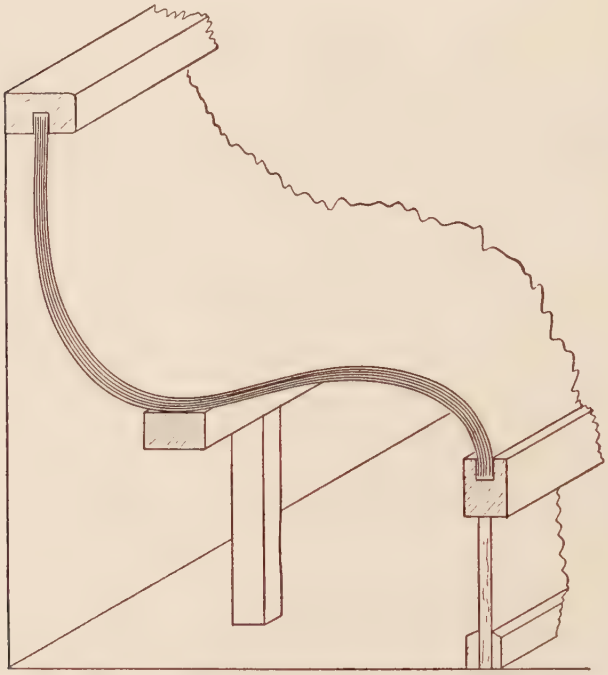

Illustration 48. Showing station-seating, formed from 5-ply veneer, supported at both edges.

modate the human form, somewhat as indicated in Illustration 48. Such settees often have perforated seats and backs.

Perforated chair seats, to replace worn-out cane seats, were once rather a large item in the plywood business, but have to a considerable degree been displaced by upholstered, genuine and imitation leather, and fibre board seats. The base of many upholstered seats and the backing of some other types of seats

still continue to be of plywood, formed with a slight downward "dish."

## Shaped Cases

The same method used in shaping seating can be used to produce covers and cases for many home, office and traveling appliances, some of which are suggested below.

Sewing-machine covers, before the advent of the disappearing feature, were almost always of veneer and often served not only as a cover, but as an operator's seat as well. The modern endeavor to camouflage a sewing-machine as a table, cabinet, or other piece of living-room furniture, has somewhat lessened this adoption of plywood.

Typewriter cases are frequently made of shaped plywood, finished to match office desks. The curved portions are usually veneered, and the end or flat portions are of solid wood.

Cases for band and orchestral instruments, often of most irregular and sometimes grotesque shapes, are made of veneer and plywood, usually cloth or leather covered, and plush lined.

The rounding cylindrical tops of old style trunks were veneered plywood, and the crowned or dome tops of the modern wardrobe trunks are made in forms like the opera seats. Such dome tops when thoroughly "set," covered with cloth inside and out, with metal bindings, are almost indestructible, and offer great resistance, even to the expert and accomplished "baggage smasher."

The curved plywood bodies of sleighs are an example of unusual strength with extreme lightness.

Car and cab ceilings are made of curved plywood, as are many of the interior fittings, partitions and the like. Bus and delivery body sides can be made of any shape desired. The uses of plywood in the transportation trades are most numerous, and will be greatly increased when the waterproof gluing of veneer into plywood is better understood.

## Grand Pianos

The making of a grand piano rim is an interesting piece of plywood work, and an achievement that could not be accom-

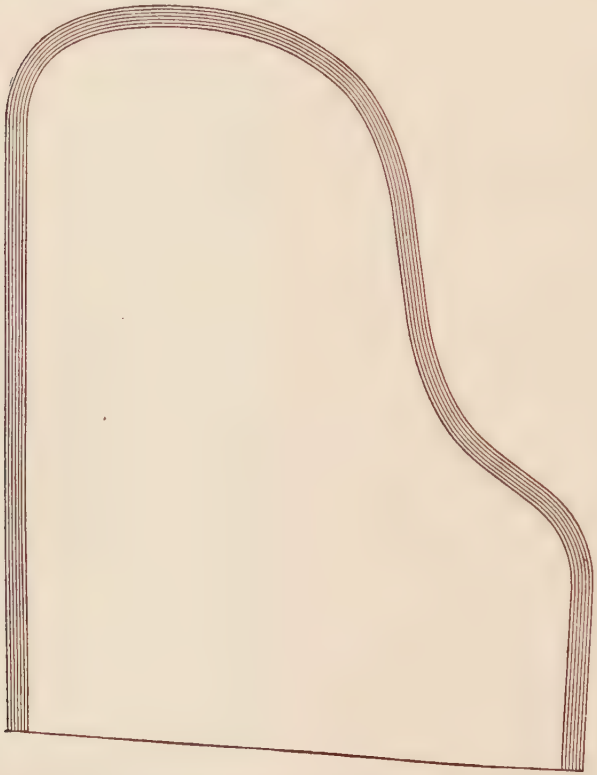

Illustration 49. Plywood as glued up for grand piano rim. Grain of wood, usually 1/8 to 3/16 inch thickness maple or poplar, in most instances goes around rim, all layers parallel.

Courtesy, Mason & Hamlin Co.

plished in solid wood, as can be appreciated from Illustration 49. The outer rim consists of six or seven layers of ⅛ or 3/16 inch veneer, all laid together with grain in the same direction. The inside and outside veneers are usually of such woods as

mahogany, rosewood, or walnut; the center veneers are concealed and may be of any strong, sound wood. The inner rim or skeleton that carries the plate and sounding board is usually of some ten or more layers, snugly fitted in the bottom of the outer rim.

### Other Musical Instruments

Stringed instruments, of the violin and banjo families, are made of veneer and plywood, and some combine curved shapes with beautiful matching of figure and artistic inlays. Drum sides, if drums may be termed musical instruments, are usually made of veneer. Commercially speaking, the volume of veneer used in these smaller musical instruments is not large, but it is, however, a most important use from an artistic standpoint.

# CHAPTER XV

## ENGINEERING ASPECTS OF PLYWOOD

Laminated wood, built up of thin sheets alternating in direction of grain, is stronger than an equal thickness of ordinary wood for several reasons, among them the following which clearly come within the engineering field.

### Tension and Compression

Wood will resist a much greater tension and a much greater compression, per unit of sectional area, in the direction of the grain (the fibres) than it does at right angles (or 90°) thereto.

### Resistance to Shear

This same difference occurs in resisting shear, or the force necessary to make one part slide (or shear) by another part on a given line or plane. In shear, however, the wood will resist a greater force along a plane perpendicular to the grain than along a plane parallel to it. Furthermore, in a plane parallel to the grain, it has higher resistance to shear sidewise, at 90° to the grain, than along the grain. In other words, the resistance of wood to shearing is less along the grain than in any other direction.

### Bending

There can be no bending without the development of tension and compression. Wood has a much greater resistance to bending in the direction, or lengthwise, of the grain than sidewise, or at 90° to the grain. If, therefore, it were possible to

have an ideal form of wood construction with the fibres running in both directions, it would provide an equal strength in every direction so far as tension and compression are concerned.

Furthermore, the bending of an object of uniform thickness produces the maximum tension and compression per unit of sectional area at the outer and opposite surfaces. That is, when an object is bent, there is a pulling apart or tension on the convex side and a pressing together or compression on the concave side. Somewhere between is a point at which there is neither pulling nor pressing, which is called the neutral axis. As the tension and compression are zero at this neutral axis and maximum at the opposite surfaces, it can be easily seen that a relatively small thickness at each surface supplies the great bulk of the tension and compression, which together constitute the resistance to bending. That is the chief reason why a thickness of veneer, perhaps one-sixth of the total thickness of a board, placed with parallel grain on top and bottom, of an inert substance, will supply nearly all of the tension and compression strength supplied by a solid board of equal thickness.

## Cross Laminations Distribute the Load

When such a laminated board is made with similar cross layers directly under these outer layers, the board will have a similar resistance to bending in the opposite direction, but not so great because the layers are nearer together and act largely as a board of so much less thickness. If, however, the length of span sidewise is reduced so that its square is in the same proportion to the square of the length of the main span as the relative distance between the centers of the inner and outer veneers, approximately, the board will have practically equal resistance to bending (or equal strength) in both directions, other things being equal. The result is that the load will be distributed when supported continuously on four sides, and

therefore require much less thickness than solid wood, depending on the arrangement of the veneers and the relative length of span in each direction.

There can be no resistance to bending, even when the resistances to tension and compression are supplied, unless there is also provided a resistance to longitudinal shear. Several thin layers just placed together will offer little resistance to bending, and carry but a relatively small load, because they bend independently of each other, and have no bond to unite them so as to resist sliding upon each other in the direction of the span; and thus they fail to bring into use the full strength of the outer layers. This resistance is known as longitudinal shear. It is necessary, therefore, that the successive layers should be firmly bonded together by means of glue.

Since wood, as stated before, has a greater resistance to shear sidewise, than along the grain, and because this shear in bending acts in the direction of the span parallel with the top and bottom fibres, it is perfectly apparent that layers of veneer placed crosswise increase this resistance to this longitudinal shear. As wood is liable to fail as much in longitudinal shear as in tension and compression, these alternate layers of cross veneers materially increase the ultimate resistance to bending in both directions.

## Combined Resistance

In effect, therefore, when the grains of the alternate layers are, by construction, at right angles to each other, one layer supplies a maximum resistance either to tension or compression, the next to longitudinal shear in one direction. Adjacent layers act with a maximum resistance in the reverse direction.

As a matter of strength of materials and of mechanics alone, the use of laminated veneers does not increase the resistance to vertical shear. Vertical shear is the tendency or force of a load on a span, acting in opposite direction to the support, to shear across the object. When a piece is supported

on four sides, however, the load is divided and passes to each pair of supports, and in this way reduces the effect of vertical shear at any cross section.

## Influence of Glue

The use of glue, however, undoubtedly helps this shear resistance, but as wood does not as readily show failure from vertical shear as from the other forms of stress, transverse shear does not enter largely as a factor into this case.

The effect of using glue in bonding the alternate layers is an important factor. The application of glue to wood acts not only as a binder between surfaces, but in so far as it penetrates the wood fibre, acts as a binder between the fibres themselves. It also provides this resistance to longitudinal shear, depending upon the quality of the layers, and thus increases total resistance to all forms of stress. It does this because good glue generally is stronger than the element of adhesion that nature provides between wood fibres.

As the penetration of the glue into the wood is not great, its influence on the ultimate strength of thick layers, other than at their immediate junction, is not appreciable. In the case of such laminated veneers as have been described, however, particularly inner veneer layers, glued on both sides and treated under heat and pressure, the penetration is an appreciable proportion of the lamination, and adds to the aggregate "built-up" boards, an appreciable resistance to all forms of stress.

Cross veneering or cross layers also have a tendency to counterbalance stresses and uneven shrinkage in the wood, and thereby prevent the manifestation of the internal stresses that are an element of weakness in solid wood.

## Summary

These reasons may all be summed up in the statement that plywood made of relatively thin layers of veneer, with the

direction of grain alternating, owes its valuable and economic qualities to the fact that this arrangement, properly applied, utilizes all of the strength of the wood to the best possible advantages in resisting the several kinds of stress and deformation that occur in all forms of bending and torsion.

Government tests at the Forest Products Laboratory have proved that plywood at its best is stronger per pound weight than solid steel.

## Applications

This multiplication of wood strength, secured by the laminations of veneers into plywood, opens a new field of great usefulness that has scarcely been seriously considered as yet. There is as yet no simple and effective process of rendering wood entirely waterproof. At the present time, certain glues are more waterproof than the wood they join together. In other words, immersion of plywood in water will not soften or dissolve a properly made and applied casein or blood albumin glue. Such immersion, however, will eventually penetrate the openings of the wood sufficiently to shrink or swell the wood fibres enough either to tear them apart, or to tear them away from the glue. When such immunity from water saturation becomes practicable, the opportunities for the development of plywood along mechanical lines are almost unlimited.

## Automobile Construction

Disc automobile wheels, with web of plywood instead of metal, will greatly reduce wheel weights and are already in the experimenal stage, giving much promise of great success. Laminated side frames afford wonderfully easy riding qualities to one popular make of car. Plywood bumper bars afford unusually resilient and elastic properties, and do not so easily mark and damage the opposing car as metal bumpers. Bus and

delivery body sides and tops are formed in plywood, resulting in a maximum of strength with a minimum of weight.

## Airplane Requirements

During the World War, plywood of veneers proved to be light and strong and was largely used for fusilage and wing construction. Propellers were made of another type of plywood which might be described as laminated lumber. The speed of a propeller tip was enormous, and lightness in weight was essential to reduce centrifugal force, and the resulting strains and stresses. When this country seriously undertakes the development of a protective as well as a commercial air policy, the opportunity for the use of plywood in airplanes will be greatly enhanced.

## Plymetal

Not only is it possible to produce combinations of different woods, through a series of thicknesses, and through various methods of assembling wood veneers, but a new field appears, in which wood fibre board and metal may be "plied" together in various combinations. This will require a careful study of suitable glues and adhesives, but the opportunity is most promising.

## Conclusions

The engineering field offers many other openings for the economic and effective use of a plywood that is strong for its weight, as well as thoroughly waterproof.

The maker and the user of plywood may well join forces in striving to bring about a better understanding of plywood in its many aspects, in intensive development of the processes of making plywood, and a broader utilization for both the artistic and utilitarian purposes.

# PART III

# THE MANUFACTURE OF VENEERS AND OF PLYWOOD

# CHAPTER XVI

## HISTORY OF VENEER MAKING METHODS

### Ancient

The earliest use of veneer has been shown to be largely for the purpose of display and ornamentation and to be little, if any, for the purpose of artistic balance, mechanical perfection or durability. The records to be found regarding this early veneering are so fragmentary, that their process of manufacture and application are almost entirely drawn from an examination of the few masterpieces preserved in the tombs of Egyptian monarchs. Some of these pieces date from the 15th and 14th Centuries before the Birth of Christ.

In addition to the furniture from Egypt, there are a few interesting relics of tools with which it was made. Votive offerings of workmen have been discovered under the foundations of many temples. It was the custom, when laying foundation stones, for those who were to work upon the buildings to be erected thereon, to place under the stones certain tools to propitiate the spirits of the temple.

It would appear that the use of veneer was regarded as a royal prerogative. In other words, veneered furniture was the best that could be made and, therefore, was only qualified for use in the palaces and courts of the reigning families.

Egypt and Nineveh knew of inlaying, veneering and cane work and we have evidence that their workmen achieved fame in those arts as have their many successors.

The furniture of Assyria has all perished, and it is only from sculptures that any of it can be understood. Furniture reproduced in pictures, or in the form of reconstructed models,

may be of little interest to the home connoisseur, and yet it is worth while to inquire into the furnishings of the homes of the nations of the past, in order that the inspirations which have governed the artists of more modern days may be fully understood.

We have seen that the art of the Far East and of Asiatic nations influenced Grecian artists, and that from Greece, artistic conceptions spread westward.

One of the most complete descriptions of the early use of veneer comes from the elder Pliny, who lived during the prime of the Roman Empire, and tells us:

> The wood, too, of the beech is easily worked, although it is brittle and soft. Cut into thin layers of veneer it is very flexible, but is only used for the construction of boxes and desks. The wood, too, of the holm oak is cut into veneers of remarkable thinness, the colour of which is far from unsightly. . . .
>
> The best woods for cutting into layers and employing as a veneer for covering others are the citrus, the terebinth, the different varieties of the maple, the box, the palm, the holly, the holm oak, the root of the elder (or alder), and the poplar. The alder furnishes also, a kind of tuberosity, which is cut into layers like those of the citrus and the maple. In all the other trees, the tuberosities are of no value whatever. It is the central part of trees that is most variegated, and the nearer we approach to the root the smaller are the spots and the more wavy. It was in this appearance that originated that requirement of luxury which displays itself in covering one tree with another, and bestowing upon the more common woods a bark of higher price.
>
> In order to make a single tree sell many times over, laminæ of veneer have been devised; but that was not thought sufficient—the horns of animals must next be stained of different colours, and their teeth cut into sections, in order to decorate wood with ivory, and at a later period, to veneer it all over. Then, after all this, man must go and seek his materials in the sea as well. For this purpose he has learned to cut tortoise-shell into sections; and of late, in the reign of Nero, there was a monstrous invention devised of

destroying its natural appearance by paint, and making it sell at a still higher price by a successful imitation of wood.

It is in this way that the value of our couches is so greatly enhanced; it is in this way, too, that they bid the rich lustre of the terebinth to be outdone, a mock citrus to be made that shall be more valuable than the real one, and the grain of the maple to be feigned. At one time luxury was not content with wood; at the present day it sets us on buying tortoise-shells in the guise of wood.[1]

## Medieval

Artistic expression, in the decorative use of veneers of wood, ivory and precious metals during the days of ancient splendor, was followed by some thousand years of turbulent strife and social unrest, a period in which all fine arts suffered, including the art of veneering.

## Renaissance

Not until the late Renaissance period do we find substantial evidence of the resumption of the ancient art of veneering. In the late Jacobean or Carolean period, we find whorled or "oystered" veneer made from the transverse slices of small alder boughs, and we also first discover the use of walnut veneer in limited quantities when this wood was expensive and still regarded as one of the semi-precious woods.

The presumption is that the veneers of this period as well as those of antiquity were produced by hand-sawing wood as thin as this operation would permit, followed by a hewing, shaving, adzing, or planing process to the required degree of thinness. There is some evidence to show that certain veneer craftsmen attached the heavier sheets of veneer to the base by the use of glue and plugs, and then worked these thicker sheets down to the desired thinness. When it is realized that the most artistic figures in wood are the result of cross-grain or

[1] Pliny's Natural History, Book XVI, Chap. 84, Bohn's translation.

the exposure of end-grain, it gives an idea of the enormous amount of hand labor and patience involved in the making of veneer by the old and crude hand methods.

It was not until about the year 1700 that we find manifestations of duplicate patterns or figure matching, both of which required the use of veneer to permit the pairing, halving or quartering of patterns, by the use of adjacent and almost identically marked sheets of veneer. Two adjacent boards of substantial thickness will seldom show the same figure, but six or eight thin sheets of veneer will be so much alike that it is often hard to tell the order in which they were cut from the log.

The vogue of spacing into panels, generally formed of an oval with four triangular corners (See Illustration 50), probably owes its conception to the copying of the Jacobean carved panels of the period immediately preceding the accession of William III. Furniture was designed usually with flat surfaces to permit of the veneers being easily laid down without splitting or the marquetry "springing."

References to history of the furniture of the 18th Century indicate the popularity of marquetry and other forms of veneering in French furniture (see Chapter IV) and the extensive use of mahogany and satinwood for veneering in the Georgian Period (See Chapter VII).

## Modern

The invention of the circular saw took place about 1805 (shortly after the advent of the steam engine), all previous sawing having been done by means of the hand or stroke saws. It was not until after this invention that the first type of slicing or shaving machine was developed for cutting thick shavings of wood that were used for boxes and for ornamental purposes. This machine was a large power-drawn plane, operated by means of a steam engine, but this method of making slices of veneer was not extensively used, and in fact, the power

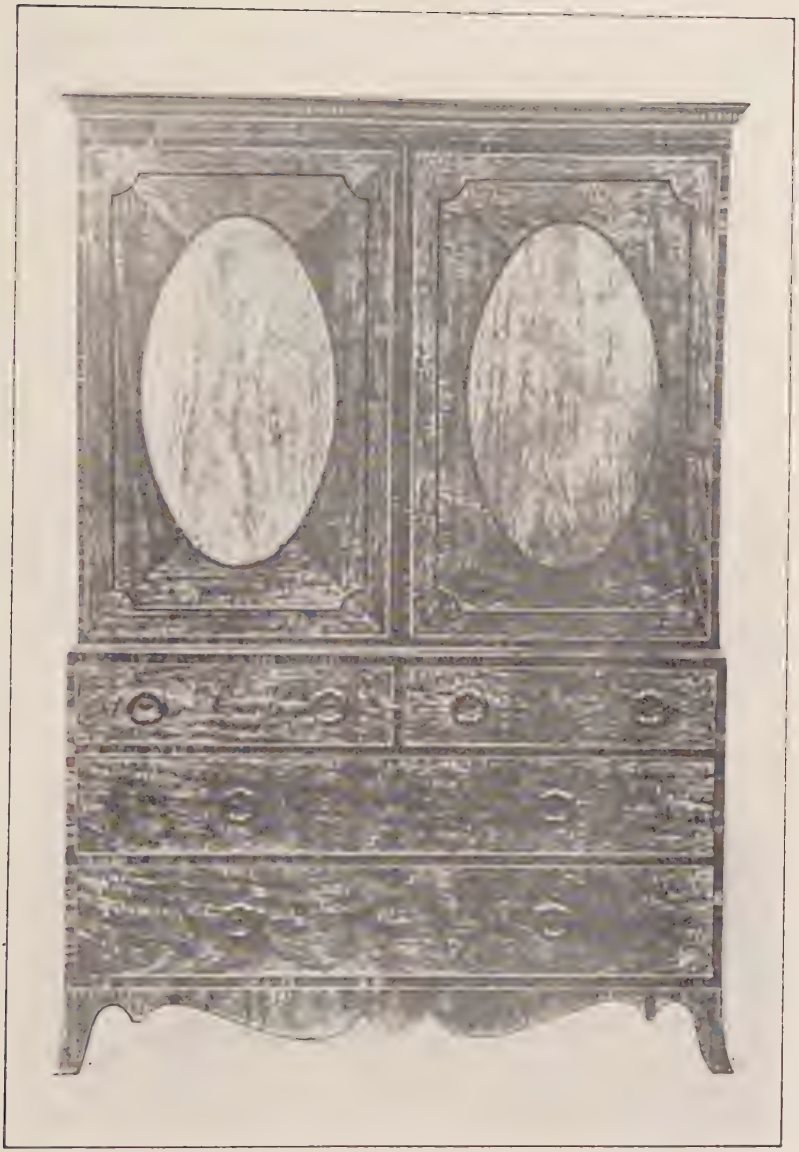

Illustration 50. Mahogany and Satinwood Clothes Press, with doors of ripple and fiddle-back mahogany showing combination of diamond and oval panel. Date 1785, approximately. Plywood construction throughout.

Courtesy, G. P. Putnam's Sons, publishers of "A History of English Furniture," by Percy Macquoid.

plane device could hardly be considered a success at that time.

The prototype of the modern circular saw was found to destroy, in sawdust, a thickness considerably greater than the resulting veneer, and this led eventually to the segment saw, which consists of a series of thin segmental toothed saw sections bolted around a center disk or hub.

The sawing process of producing veneer was supplanted in the latter part of the 19th Century by the slicer, a knife across which a log is drawn, producing a shear cut, and resulting in a shaved sheet of thin lumber. This slicer was the original method and is still used for cutting the most valuable veneers where figure and texture are important.

The most recently developed method of veneer cutting is the rotary lathe, producing sheets of substantial width and length, peeled off cylindrically from a log in one continuous piece. This has now become the chief means of veneer production in all except figured woods.

These historic types of veneer cutting machines are interesting only as stages in the development of the modern machine, described more fully in the chapters following.

# CHAPTER XVII

## MODERN MANUFACTURING METHODS

### Outline

It has been thought wise to arrange the description of modern veneer making methods in somewhat cumulative form, showing first, diagrams of the different methods of cutting and the position, in the log, of veneer cut by each method; following this is a brief description of the principal types of cutting machines, with sectional drawings showing operation and veneer delivery.

The next Chapter (XVIII) gives photographic reproductions of the different veneers that are frequently found in modern industrial work. Where certain woods are commercially made into veneer by more than one cutting method, the cutting characteristics are shown or described. Still other woods may require additional identification suggestions for curly, mottled, stump, crotch and the like.

After the reader has secured this background of the rudiments of cutting methods and the principal types of veneer woods, it becomes possible to give more graphically in Chapter XIX pictorial and narrative descriptions of modern veneer cutting mills.

### Veneer in the Log

There are four ways of converting logs into veneer and all are in general use at the present time.[1] Diagrams of the various methods are shown comparatively in Illustrations 51 to 54.

If these are to be arranged according to volume of production, *rotary cutting* will easily stand at the head of the list,

[1] See Illustration 193, page 341. Here rotary cutting includes half round.

since most plain veneers are so made, as well as some figured woods. The veneer is spirally unrolled from the log, some-

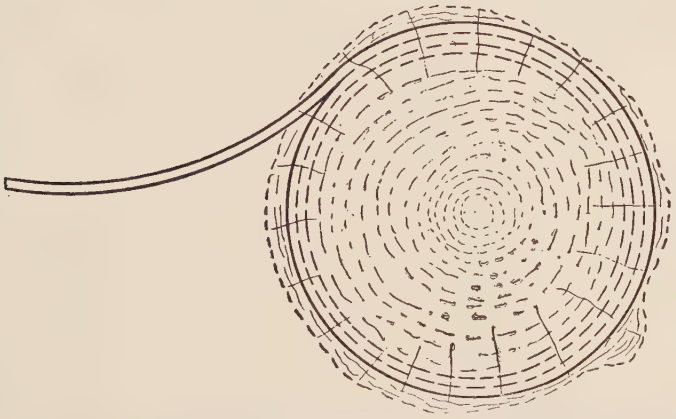

Illustration 51. Showing how rotary veneer is cut from a log or bolt, after the uneven exterior has been cut away. Note the probability of irregular figure with no two sheets alike.

what as paper is unwound from a roll. Logs never grow perfectly symmetrical, so that a sheet of rotary veneer may show

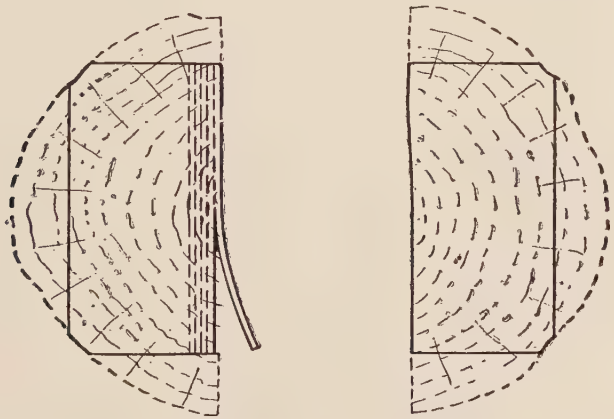

Illustration 52. Showing how sheets are sliced from hewn (or sawed) log, sometimes halved and quartered. Note the probability of almost identical figure on adjacent sheets.

parts of several growth rings. Hence, rotary cutting shows large, "sprawly" grain, as in oak, ash and fir.

*Slicing* veneer is the standard cutting practice for mahogany and most other figured woods. The sheets of veneer are sheared from the flat surface of a hewn log or sawn flitch.

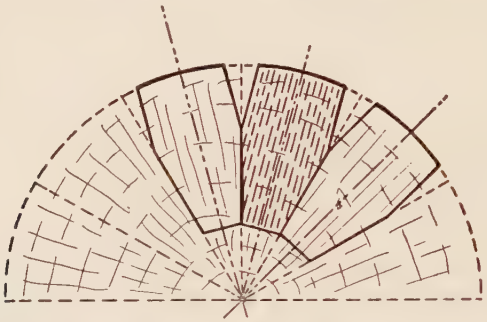

Illustration 53. Quarter sawed veneer is made from segmental flitches, as the sections are called, and obviously only one sheet of veneer in each flitch is genuinely quartered. The remaining sheets have enough figure to grade as "quartered." Sometimes quartered veneer is sliced from sawed flitches.

These cuts extend across many or few growth rings, according to distance from center of log. Sliced veneer is some-

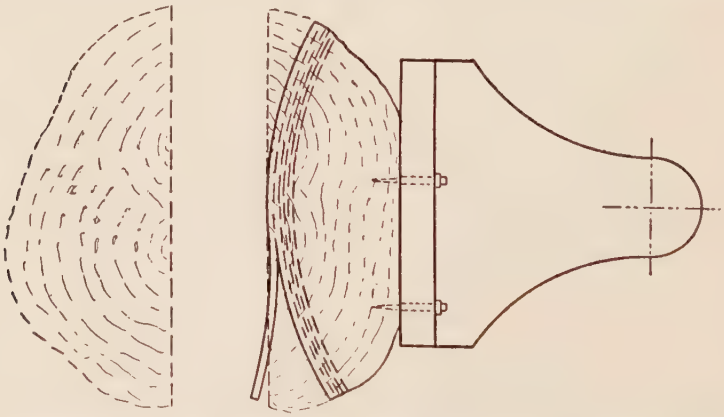

Illustration 54. One method of cutting "half round," showing how a crotch can be halved (on a saw) and cut into similar adjacent sheets to reveal the beauties of heart crotch figure.

times cut radially (quartered) but is usually random cut, as above.

*Sawing* veneer with segment saws, although the earliest modern method, is chiefly used for quartered oak. The saw kerf waste is equivalent to the thickness converted into veneer, hence the method is not economical, and is applied only to woods and products that cannot be cut advantageously by any other method.

*Half round* cutting is done on a lathe by the use of a "stay log," an eccentric device that permits rotary cutting on a wider sweep, or with greater diameter, than when log is mounted on usual lathe centers. Circular sheets, instead of cutting from outside of log towards heart, may be cut from heart towards the outside.

## Veneer Cutting Machines

The modern methods of manufacturing veneer are practically three-fold, the oldest being sawn, the later, sliced, and the recent, rotary cut.

Segment Saw. Sawn veneer undoubtedly dates back to antiquity when sheets of veneer were hand-sawed and shaved down to required thinness. The invention of the circular saw in the early 19th Century made it possible to cut as thin sheets as were desired, allowing only for the necessity of smoothing down the rough saw marks. The circular saw of large size was made of relatively thick metal with considerable "set" for clearance, more lumber (often 1/8 inch) was destroyed in the form of kerf, or sawdust, than was produced in veneer. This led to the modern segment saw, at present used chiefly in the production of quarter sawed oak veneer, with which when intelligently operated it is possible to reduce the loss from saw kerf to approximately 1/16 inch and sometimes to 1/20 inch.

A large proportion of the veneer produced on the segment saw is quartered oak, since most other woods yield to the slicing method without tearing. Only about five per cent of the total veneer production is cut on a saw. The flake, or "splash"

of oak, is an opened section of the medullary ray, containing horizontal cellular growth, and this figure tears easily when sliced. Sliced quartered oak is cheaper, as no saw kerf is lost, but it is often distinctly inferior in quality of workmanship.

The usual design of segment saw consists of a large cast hub to which many small segmental sections of a saw are bolted, shown in outline in Illustration 55. This permits the use of thinner saw steel and less "set," since succeeding sheets of veneer are thin enough to be bent away from tapering hub and thus obtain necessary clearances. The saw revolves towards the log and the face of the saw against the log is flat. The log or "flitch" to be sawed is bolted or clamped to a traveling carriage mounted on metal ways. This carriage, not only has reversible lengthwise travel, but has, as well, a screw adjustment, towards and away from the saw, usually graduated in fractions or decimals of an inch. It is customary to move the flitch away from the saw a trifle for clearance on the return, or non-sawing stroke.

The segments of the saw must be carefully mounted so that the saw will run true, and the teeth should be filed and set by an experienced mechanic to control necessary clearances and to reduce visible saw marks to a minimum.

Sawed veneer, after drying, is customarily kept in complete logs or flitches, usually tied in bundles, and frequently segregated as to widths and character of figure. From an exact standpoint, only one sheet of veneer from each flitch is strictly quartered, and that only when the tree grew phenomenally straight and true. Other adjacent sheets are imperfectly quartered.

Veneer Slicer. The loss of at least half of a valuable log (or flitch) in sawdust, prompted the development of a knife slicing or shearing machine, which was first in the form of a gigantic plane drawn by means of a steam engine. This plane produced shavings that could be used for decorative pur-

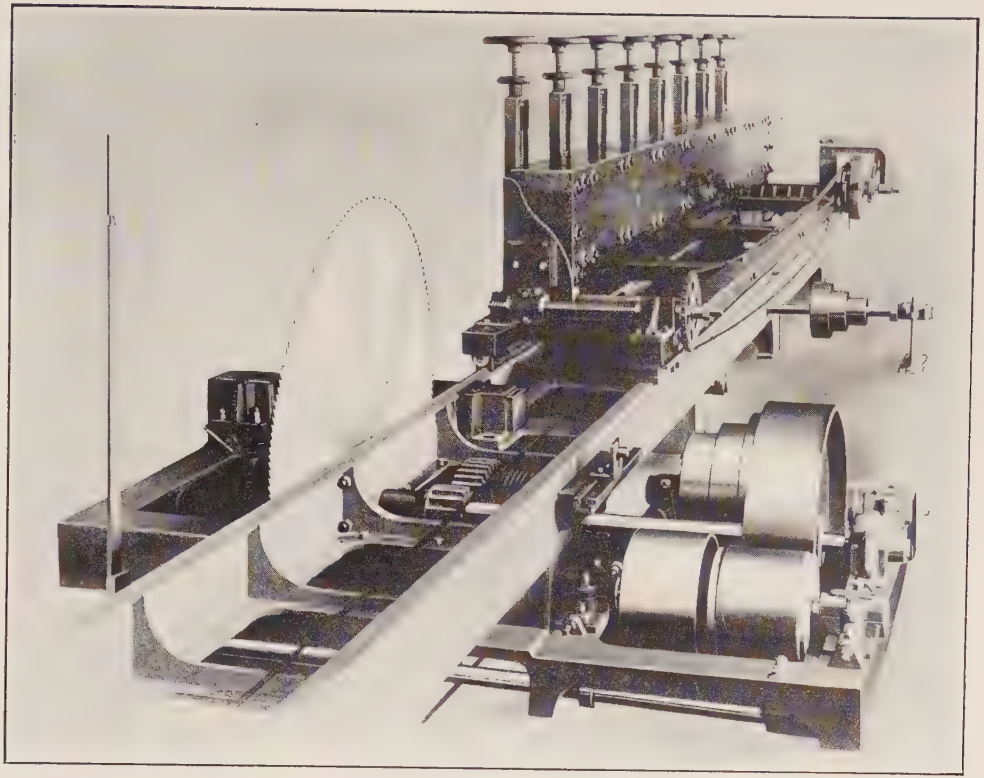

Illustration 55. Segment saw, showing flat face of saw that is in contact with flitch during sawing process. Reciprocating carriage to hold flitch is in background.

Courtesy, Louis L. Seibert & Co.

poses, but the device was lacking in ability to cut cross- or end-grain satisfactorily without splitting and breaking. From such a large plane came the development of a shearing knife, properly mounted, and drawn against the surface of the log to be converted into veneer. Such a knife cutting process obviously produced no sawdust and converted the whole log into veneer, without saw kerf, a substantial material saving.

It will be observed in Illustration 56 that the hewn or sawn log is bolted to a base and the log drawn diagonally across a sharp knife, producing a shearing motion. The shearing motion cuts cross- or end-grain with a minimum of splitting and tearing and gives a clean cut, particularly in cross-grained portions of figured, crotch, stump and burl logs, where much of the slicing must be at sharp angle against the grain of the wood.

In order to secure the desired thickness of veneer, the knife and the log are fed towards each other by means of a mechanical screw or ratchet which operates only between cuts. It is to be observed in the slicing of veneer that not only is there no loss whatever of saw kerf, but the adjacent sheets produced are almost identical in character, in figure and in color.

Not over five per cent of commercial veneers are produced by the slicing method. It is inevitable, however, that the sheets of veneer as they fall from the knife, are somewhat bent and the surface grain slightly checked by this bending. In the sawed veneer, there is practically no bending nor strain of the fibre, and sawed veneer is, therefore, absolutely "tight cut." Sliced veneer has only a little open grain due to the shear cutting and clearances for knife movement and is, therefore, nearly "tight cut." Slicing is seldom used for greater thicknesses than 1/12 of an inch, and for all practical purposes sliced veneer may be regarded as having tight surfaces.

Rotary Lathe. The third, and relatively modern method of cutting veneer is by means of a lathe, and this is the means

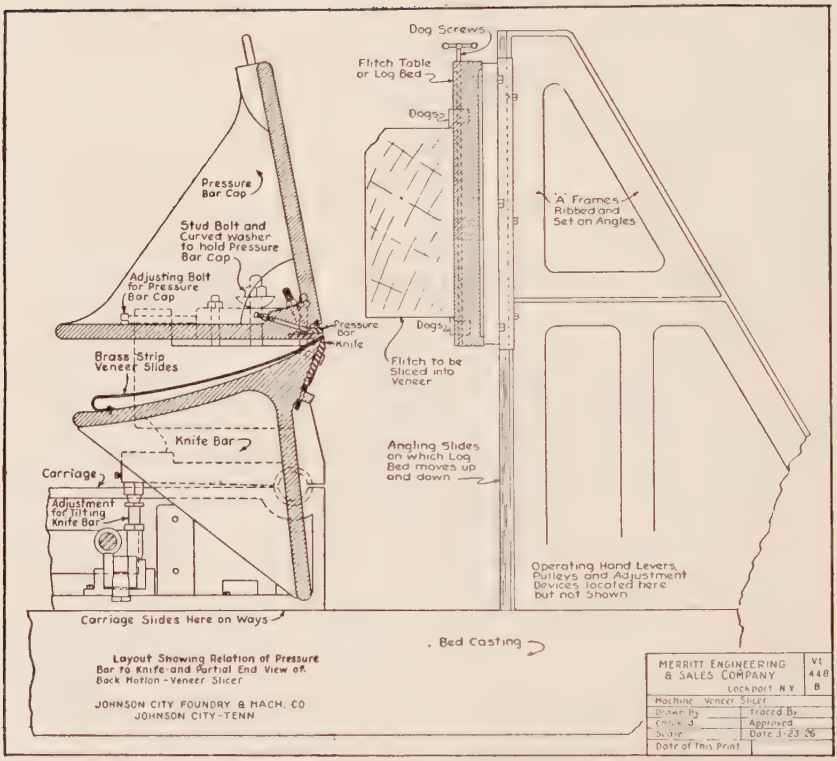
Dog Screws
Flitch Table or Log Bed
Dogs
Pressure Bar Cap
Stud Bolt and Curved Washer to hold Pressure Bar Cap
Adjusting Bolt for Pressure Bar Cap
Pressure Bar
Knife
Dogs
Brass Strip Veneer Slides
Flitch to be Sliced into Veneer
"A" Frames Ribbed and Set on Angles
Knife Bar
Angling Slides on which Log Bed moves up and down
Carriage
Adjustment for Tilting Knife Bar
Operating Hand Levers, Pulleys and Adjustment Devices located here but not Shown
Carriage Slides Here on Ways
Bed Casting
Layout Showing Relation of Pressure Bar to Knife and Partial End View of Back Motion - Veneer Slicer
JOHNSON CITY FOUNDRY & MACH. CO
JOHNSON CITY - TENN
MERRITT ENGINEERING & SALES COMPANY
Lockport N.Y.
VL 448 B
Machine Veneer Slicer
Drawn By
Traced By
Checked
Approved
Scale
Date 1-23-36
Date of This Print

Illustration 56. Cross section of a Veneer Slicer, showing in detail the cutting mechanism at the left and indicating in outline, on the right, the reciprocating flitch table that moves up and down on the angling slides. The flitch is shown some distance from knife to preserve details.

Courtesy, Merritt Engineering & Sales Co.

employed to produce approximately ninety per cent of the veneers of today. Since the process involves the mounting of each log in a lathe and revolving the log against a cutting knife, it is obvious that the rotary cutting of veneer must be done with little regard for the figure of the wood and, therefore, this cutting method seldom is employed in other than commercial grades of plain wood.

There are a few exceptions to this, however; for instance, "bird's-eye" maple, etc., in which the figure or "bird's-eye" consists of radial blemishes, which are most pleasing when rotary cut; some of the curly figured maples are also lathe or rotary cut.

Rotary cutting is more of a strain on the fibre of the wood than either sawing or slicing, since the sheet that was wrapped

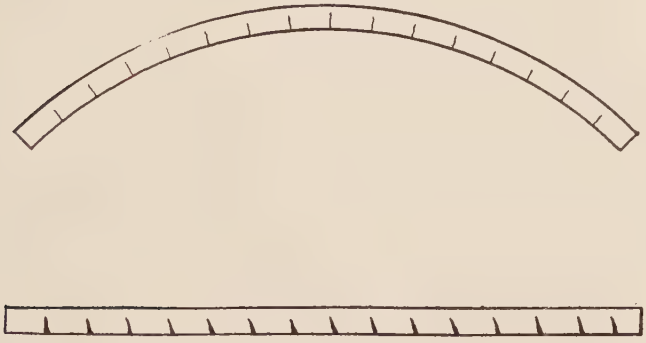

Illustration 57. Showing, in exaggerated form, why rotary cut veneer, when flattened out will have cutting checks, observable on the under (convex) side to a greater or less degree, according to thickness of veneer and skill of operator. Upper sketch shows sheet of rotary cut veneer allowed to assume its natural shape, with checks hardly perceptible, and lower sketch shows same sheet flattened out and checks correspondingly opened.

around the log is straightened out flat and dried in that condition. The outside surface of the veneer will be under compression strain, and the inside under tension. In exaggerated form, it is shown in Illustration 57.

These are called cutting checks, and a thin veneer, with almost imperceptible checks is said to be "tight cut," whereas a

thick veneer (1/8 inch and up) will have checks apparent to any careful observer and is said to be "loose cut." The degree to which thick veneer is "tight cut" reflects credit on the skill of the lathe operator. In laying veneer for plywood, it is customary to have the convex side uppermost, so that cutting checks on the concave side are concealed and also offer an opportunity for the glue to take a firm hold.

The modern rotary cutting machine (See Illustrations 58 and 59) consists of a massive, sturdy lathe of considerable size

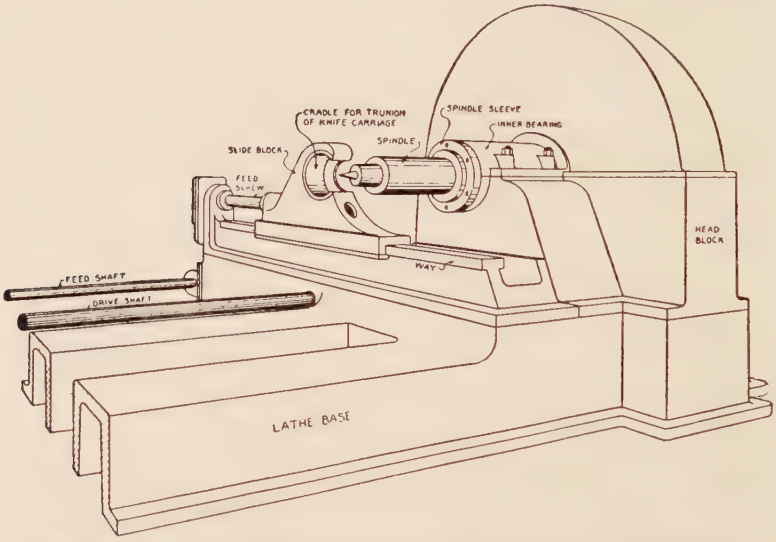


Illustration 58. Diagramatic view of veneer cutting lathe, without knife carriage or log, showing details of feed and drive mechanism.

Courtesy, Merritt Engineering & Sales Co.

with centers about six inches in diameter. These centers, operated lengthwise by screw feeds, are forced into the ends of each log to grip firmly for rotating. The log is revolved against a taper-edged knife, and the resulting veneer emerges between an adjustable pressure bar and the cutting edge of the knife, flowing out in a wide sheet. The length, with the grain, is determined by two spurs or knives forced into the log surface,

in advance of the cutting knife. The correct honing of the knife and the adjustment of the pressure bars are delicate operations that call for skill and experience.

It is generally conceded that the heaviest or thickest veneers that can be cut on a lathe are 5/16, and sometimes 3/8 inch, but

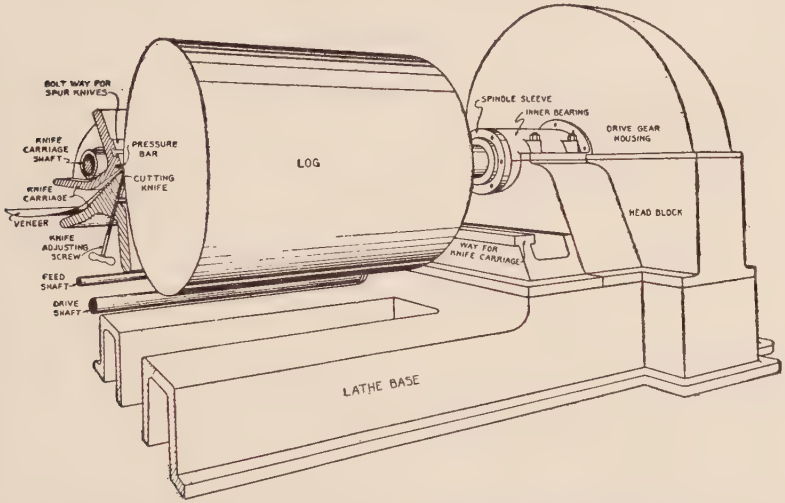


Illustration 59. Same view as last of veneer cutting lathe; but with knife carriage in place, shown at left; and log mounted for cutting veneer.

Courtesy, Merritt Engineering & Sales Co.

the opened grain and checking in such thicknesses is likely to be a serious disadvantage, except where the heavy veneers are used for cores and are concealed from view.

This rotary method of cutting veneer is obviously a rapid production process, largely regardless of figure in each sheet of veneer. It is the cheapest and most expeditious method of production, since the rotary motion permits a continuous flow of sheets of veneer as large as can be handled.

Half Round Stay Log. This is a semi-circular wide sweep, off-center, cutting device, attached to an ordinary veneer lathe. The arrangement is best shown in Illustrations 60 and 61. The stay log, as an attachment, is usually adjustable for

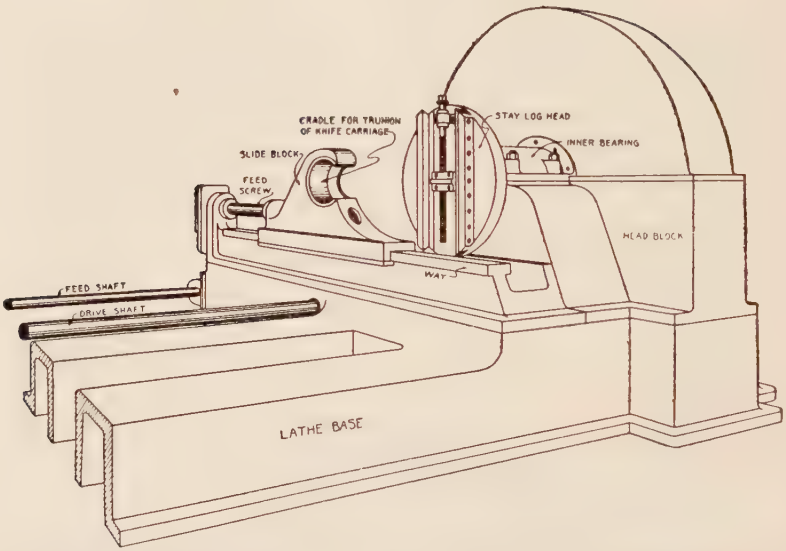


Illustration 60. Diagramatic view of veneer cutting lathe, with spindle removed and stay log head substituted.

Courtesy, Merritt Engineering & Sales Co.

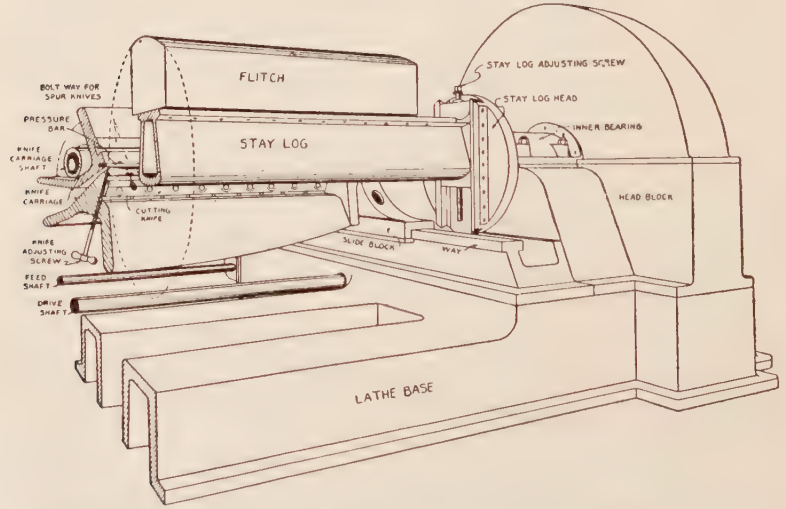


Illustration 61. Same view as last of veneer cutting lathe, with stay log attachment, showing flitch and knife carriage in position for cutting veneer.

Courtesy, Merritt Engineering & Sales Co.

the sweeps or diameter of cuts desired to be made. Practically speaking, the veneers cut on a stay log are the same as if flitches were bolted to the outside of a large cylinder; in fact, a stay log attachment is a segment of such a cylinder. Not only can the diameter of the cut be increased within the capacity of the stay log, but the cuts can be reversed, so that veneer may be cut from the heart towards the outside, rather than the normal rotary cut from outside to heart. It is used chiefly on walnut, as it permits opening a butt or crotch in a way to reveal the finest figure, and allows cutting the veneer so as to obtain the choicest shadings of end and slanting grain. The cutting procedure is described in some detail in Chapter XIX, pages 194 to 198, where the cutting of walnut is developed further.

## Standard Thicknesses

The thicknesses of veneers as commercially used are as follows:

Special. This type is used for airplane work and engineering requirements, cigar-box coverings and linings, and veneer to be mounted on paper and cardboard. These thicknesses are fragile and in most cases are laid on sheets or rolls of paper (for support) when cut.

| | | |
|---|---|---|
| 1/100 inch | 1/80 inch | 1/72 inch |
| 1/60 inch | 1/50 inch | 1/40 inch |

Figured Veneers. These veneers are mostly face stocks where character and beauty of figure are desired, and are usually produced on a veneer slicer, and kept in bundles or packages in exact sequence as cut from log or flitch. Quarter sawed oak veneer is usually 1/20 inch and sometimes 1/16 inch thick, as saw marks must be removed by sanding to a smooth surface. Occasionally, 1/8 inch veneers are sliced, as for grand piano rim stock, but this is the exception.

| | | |
|---|---|---|
| 1/32 inch | 1/30 inch | 1/28 inch |
| 1/24 inch | 1/20 inch | 1/16 inch |

Commercial Veneers. In the main, these are produced by rotary cutting on a lathe, in sheets of various sizes. It is seldom that much attention is paid to similarity of figure, and usually such veneers from so-called "plain" woods are for commercial work and sold by aggregate footage areas. Plain sawn veneers may be classified within this range when not produced to secure figure, but to obtain unusual tightness of grain, as in piano pin or wrest plank of maple.

| | | | |
|---|---|---|---|
| 1/24 inch | 1/20 inch | 1/16 inch | 1/12 inch |
| 1/10 inch | 1/9 inch | 1/8 inch | 1/7 inch |
| 1/6 inch | 3/16 inch | 1/4 inch | 5/16 inch |

## Shrinkage in Thickness

It should be kept in mind that all wet wood shrinks as it dries. Nearly all logs are steamed or soaked to make the wood easy to cut, and to produce veneers that are pliable and as free as possible from brittleness during the manufacturing processes. The thickness of veneers may be reduced from six to ten per cent by shrinkage, or to slightly less than the cut dimension. Well-made veneer should be cut a trifle "strong" for thickness. It is good practice to set knives to 1/30 inch to produce 1/32 inch stock; 1/26 for 1/28 inch; 1/22 inch for 1/24 inch; 1/18 inch for 1/20 inch; 1/15 inch for 1/16 inch, etc. Lathes and slicers are provided with suitable gear facilities to produce almost every fractional thickness that may be desired.

# CHAPTER XVIII

## VARIOUS VENEER WOODS AND THEIR IDENTIFICATION

### Classification

The classification of veneer woods, either according to botanical species, texture and growth characteristics, or the division of the well-known varieties into plain, figured and fancy veneers, both fail to offer substantial help towards ready identification.

In general, the principal figured veneer hardwoods will be briefly described and illustrated first, followed by the plain or unfigured hardwoods, although the twilight zone between is not at all definite. Following these, the softwood veneers will be outlined, none of which are figured, in the strict sense of the word, but which can be selected to develop interesting and attractive character or grain arrangements.

Brief historical items, together with suggestions as to utility and recognized advantages will be included. No attempt will be made to include more than the commercially used varieties, although a short outline of the better known historical fancy woods will be given.

### Walnut

Walnut is one of the typically American trees; growing practically everywhere in the eastern and central portion of the United States, from Canada to the Gulf.

The first walnut known to civilization was the Persian or

royal walnut. Originally a native of Persia, it was introduced westward through the ages and it now is found in the countries of western Europe. French, English or Italian walnut, as well as Circassian walnut, are local names for the royal or Persian walnut. Traces of the use of walnut have come down from the early cave men who lived in Europe during the Stone Age, as well as from the mound builders of Tennessee.

The walnut tree of early history was prized especially for its fruit, the botanical name meaning the "Nut of Jupiter," to which is added the adjective, "Royal," in describing the various European species. The acorn of the ancients was supposed to be the nut of the walnut, rather than the oak acorn. The use of walnut as a wood is mentioned in King Solomon's time and also in the days of the Roman Empire. With oak, it shares the honors of the early Renaissance periods of art expressed in wood, especially in the massive carvings of those days.

The early part of the 17th Century was the beginning of the wider use of walnut for decorative purposes in furniture, and apparently is the earliest period at which the beautiful figure of walnut veneer began to be appreciated.

The walnut trees of Central Europe were nearly all killed in the severe winter of 1709, and the exportation of the wood was prohibited by the French Government in 1720. The Dutch and Spanish craftsmen, therefore, began to import mahogany, being forced to use it to replace walnut in the furniture of that period. Following the battle of Waterloo, French walnut trees were used almost exclusively for gun-stocks. It is reported that £600 sterling was paid for a single tree and that France consumed 12,000 trees for gun-stocks in 1806.

Walnut was one of the favorite woods used in furniture throughout the "period-style" developments of France and England, and today continues to be very popular in American furniture.

American black walnut was originally a forest tree, but was

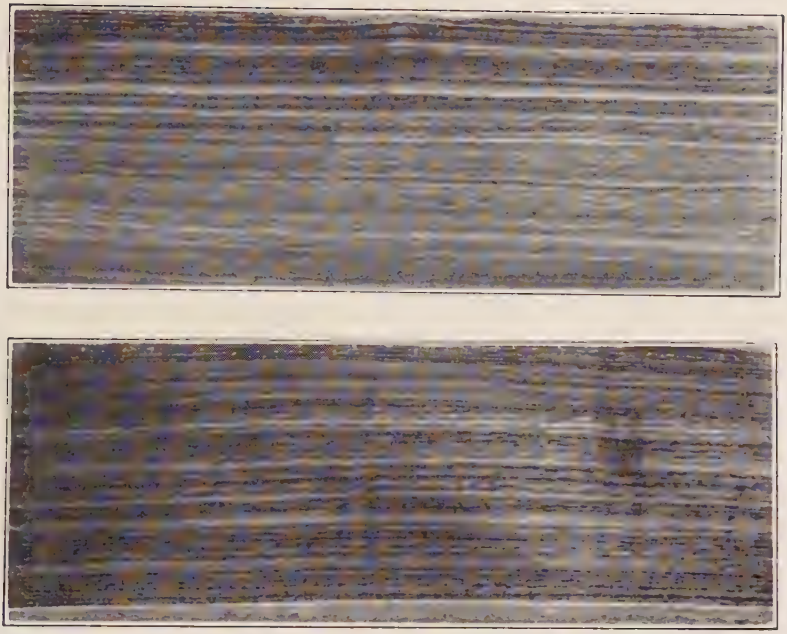

Illustration 62. American black walnut veneer, showing the typical stripe effect of the sliced wood, when cut on the quarter.

Courtesy, American Walnut Manufacturers' Association.

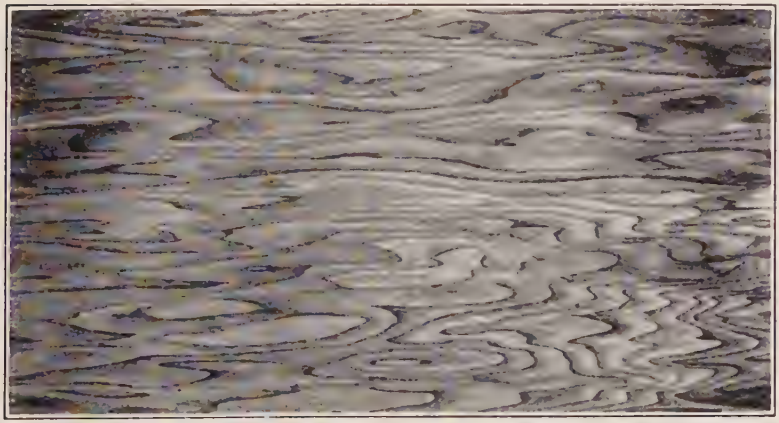

Illustration 63. American black walnut, showing the plain rotary cut veneer.

Courtesy, American Walnut Manufacturers' Association.

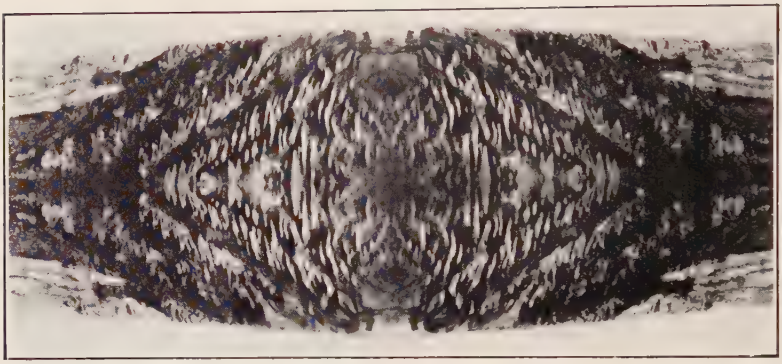

Illustration 64. Highly figured stumpwood veneer, showing typical four-piece butt-matched effect. Veneer half round cut on stay log. American black walnut.

Courtesy, American Walnut Manufacturers' Association.

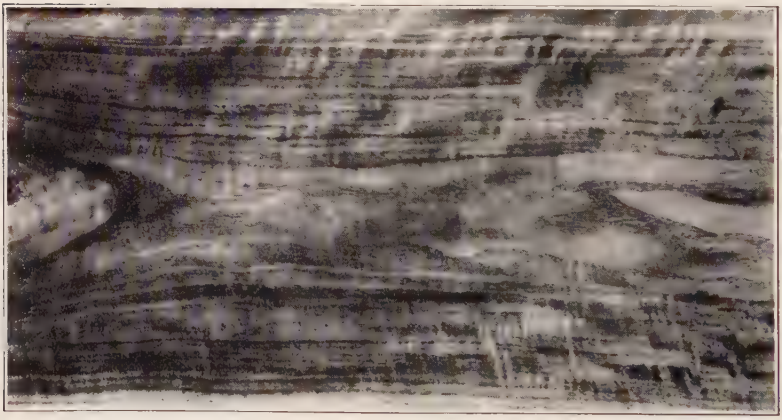

Illustration 65. American black walnut, sliced veneer, showing some stripe and cross figure.

Courtesy, Penrod Walnut & Veneer Co.

cut in advance of the other woods, so that the production decreased in volume from 1875 to 1900, and was only increased again during the period of the World War, when the strength and elasticity of the wood made it so valuable for gun-stocks and airplane propellers. Since that time, it has been unexpectedly discovered that the popularity of planting the tree for shade and fruit purposes has established a substantial supply of timber and veneers for many years to come.

The American species consist principally of the familiar *black walnut* and the *white walnut* (butternut), a smaller and commercially less important veneer wood. The rich brown shades of the black walnut heart wood make it particularly attractive in furniture and piano finishes. The sap wood in the log is thin and rather colorless. Butternut logs yield no particularly attractive veneer products, as the colouring is less desirable.

Walnut veneer is produced under many classifications and kinds of manufacture, of which the most used are the stripe and heart sliced, both plain and figured, the rotary cut, plain and figured, half round, plain and figured, quarter sliced, plain and figured, and stump wood. The latter is valued exclusively for its figure and its suitability to four-piece and butt-joint matching. It is also used for appliqué or overlay. These are shown in Illustrations 62 to 65. There are many other beautiful effects obtainable from cross figure and stump walnut veneers, giving as wide an assortment of veneer figure, matchings and arrangements as are obtainable from any wood.

Circassian walnut comes from the region of the Black Sea, being conveyed to seaboard on pack animals, and therefore is scarce and expensive. It has sharp color contrasts, with unusually unique figure.

American black walnut is practically the chief source of commercial walnut in the United States and Canada at the present time, while considerable quantities are also exported to Europe. On the other hand, the supply of European walnut

is limited and little of it finds its way to America, either as logs or as cut veneers.

## Mahogany

Trees of the mahogany family are widely distributed in the tropics. Very few of these, however, produce mahogany lumber or veneer. In addition, there are several "near" mahoganies which must be carefully differentiated from the genuine.

While ordinarily regarded as an imported wood, and not truly American, because the only part of the United States in which it grows naturally is the tip of Florida, yet it is actually more the product of the western hemisphere than of Africa, the only other source.

History makes it clear that the first public recognition of mahogany came through Sir Walter Raleigh in 1597, on one of his journeys to the almost unknown western world. The ship's carpenter found some mahogany logs with which to replace damaged timbers and decking while lying in one of the West Indian harbors. On the return trip to England it is said that Queen Elizabeth, on a visit on board ship, admired the unusually attractive and unfamiliar brown wood, whereupon Sir Walter had the timbers removed and made into a table for the Queen.

Mahogany was extensively utilized during the development of period furniture styles in France and England, and has always maintained its position as one of the choicest and most popular cabinet woods, because of its easy cutting, texture, durability, color and the wide range of its artistic figure.

Genuine mahogany comes from Cuba, San Domingo, Mexico, Central America (and adjacent portions of South America), the West Indies and the Gold, Ivory and Nigerian coasts of West Africa. It is a tropical tree, solitary in its growth, and reaching great height and size. The native logging pro-

Illustration 66. Sliced African mahogany, showing typical straight stripe veneer.

Courtesy, Mahogany Association.

Illustration 67. Sliced African mahogany, showing typical mottle and broken stripe veneer.

Courtesy, Mahogany Association.

Illustration 68. Crotch mahogany veneer, showing possibilities for wonderful matched design.

Courtesy, Mahogany Association.

Illustration 69. Sliced mahogany veneer, showing blister figure.
Courtesy, Mahogany Association.

cedure is most primitive, and the logs are often barked and those from Africa are usually hewed square to reduce weight and bulk.

The woods more or less closely resembling mahogany and at times confused with it are *prima vera* or white mahogany; *Spanish cedar,* a figureless aromatic wood largely used for cigar-boxes; so-called *Philippine mahogany,*[1] *padouk,* an East Indian wood of somewhat similar appearance; and *gaboon,* sometimes known as "Liberville mahogany." Each of these have individual qualities of value and deserve to be known by their right names rather than have their identity lost or confused with others.

Mahogany has many varieties of figure, among which are the well-known "stripe" or ribbon, "mottle," "ripple," and "crotch," shown in Illustrations 66 to 69.

Mahogany is predominantly a furniture and piano wood with considerable utilization for the interior woodwork of banks, offices, hotels and other structures requiring fine and artistic interior finish.

## Oak

Oak is without doubt one of the most important and generally used hardwoods of history and commerce. The origin of the use of oak dates back to the prehistoric age, and the sturdiness of the oak is traditional. There are many species growing in all parts of the world, and the wood is known everywhere for its strength, durability, appearance, and wide range of utility. The piles of the old London Bridge, taken up in 1827, were sound after six and a half centuries of use.

Oak was known in the days of the ancient Roman Empire, and was the dominant wood for structure, embellishment and carving in the Gothic, Tudor and early Stuart periods of furniture, giving way gradually to walnut and mahogany. Oak

[1] At the time of publication, serious question has been raised as to whether the title "Mahogany" may be used for any of these Philippine species.

was one of the principal building and construction woods until about the beginning of the 18th Century, when the softwoods began to appear. It has always been regarded as a shipbuilding wood, and is highly valued by railroads for ties, timbers and car construction, as well as by all kinds of vehicle makers for its great durability and strength.

English oak is one of the historic woods, claimed by many to be superior to the American white oak, although this opinion is by no means undisputed.

There are many species of American oaks, those most used in veneer being *white oak* and *red oak*. The white oak is cut into both quarter sawn and rotary veneer, shown in Illustrations 70 and 71. Plain sawed veneer, used especially for plywood to match the grain of solid lumber, is shown in Illustration 72. The characteristic figure and markings are more specifically described on pages 151 and 187, where the various cutting methods are outlined.

Quarter sawed white oak has been a standard wood in home, office, library and commercial furniture fittings and almost every style of home and office equipment is made in oak. Rotary cut oak, due to the ring porous growth of the wood, has a large and rather a coarse figure.

Red oak does not show as characteristic and desirable a figure in quarter sawing and is not as highly regarded for veneer work. It is not as expensive and, therefore, is sometimes used where cost is a consideration. Red oak yields a useful but a more fragile rotary veneer than does white oak.

Both plain and quartered white and red oak take an excellent finish. The color contrasts in staining are largely due to the alternate hard and soft growth rings, the latter absorbing the pigments readily and giving an attractive range of color shadings in the darker finishes.

The several varieties of oaks, found in southern river lowlands and deltas, mature rapidly and produce rather rank figure not so attractive as the slower highland growths.

Illustration 70. Rotary cut oak veneer.
Courtesy, Underwood Veneer Co.

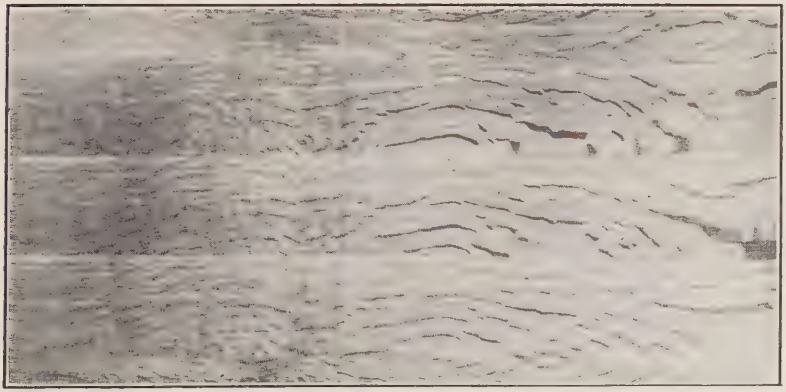

Illustration 71. Quarter sawed white oak veneer, random matched.
Courtesy, Underwood Veneer Co.

Illustration 72. Showing plain sawed oak veneer, matched in balanced strips. Note the marked dissimilarity between plain sawed, quarter sawed and rotary oak veneer, shown in two next preceding illustrations.

Courtesy, New Albany Veneering Co.

*Live oak* is not a veneer wood, but is the strongest species of oak, and largely used for transportation, vehicles and ship-building.

## Birch

This is one of the principal northern hardwoods, noted for its attractive grain figure, its density, hardness and susceptibility to high finish. It is found from Maine to Minnesota, but rarely below a line drawn from Boston to Milwaukee. Its chief veneer uses are for house trim, furniture and bent wood seating.

There are several varieties of birch which blend into each other as species and also as to grain and color of veneer. The *yellow birch* and the *red birch* are the most popular varieties for veneer and plywood for cabinet-work and furniture. The yellow birch is the most plentiful and is the first choice of the veneer producer. It has a rather thick growth of light sap wood and a red heart with a suspicion of a yellowish hue, as compared with the cherry red of the red birch. The yellow birch is inclined to be freer from defects and the peculiar cross-grain which presents decided difficulties in the manufacture of veneer and which is very common in the red birch. The red birch, while more defective than the yellow birch, produces most of the curly birch veneer and has a beautiful cherry red growth of heart wood that is highly prized in cabinet work. The *white birch* has a very small heart and is used more commonly for spools, bobbins and toothpicks but is also satisfactory for use as veneer for the manufacture of chair-seating, cross-banding and center stock. It does not possess the strength of the yellow birch or red birch and is inclined to contain numerous small pin knots, which cut smooth and do not check or drop out of the wood upon drying. The grain of the white birch has very little character and it is not so desirable for cabinet wood. The illustrations are of plain (73)

and curly (74), no attempt being made to show the red which is more a distinction of color than of grain.

While birch holds its lead among the cabinet woods through its own happy character and beauty, it also lends itself to excellent blending into the shades and colors of a large number of other woods, including walnut, mahogany and cherry. Many furniture makers use it in such combinations, sometimes without frankly giving to birch the credit it is due. The advocates of birch as well as those of mahogany and walnut deplore this species of camouflage.

Birch is stronger and less breakable for use in legs, stretchers, rockers, rounds, etc., than most other woods and is essential to the strength of the delicate-looking chairs and tables that would hardly be strong enough for practical use if made from walnut or mahogany or other beautiful woods that do not possess the same strength as birch. It is on account of the strength and toughness of this wood that it has become so popular in airplane construction, where the maximum strength for the weight of material is so important.

As an interior finish, birch has been extensively used, shaded into grays, tans, browns, and reds, as well as in natural colors. It is found in many first-class hotels, clubs, hospitals, university and office buildings, as well as in humble and in stately homes.

## Gum

Gum is an American wood of rather wide distribution and considerably diversified family connections, among which is the blue gum or eucalyptus of California. It grows almost entirely in the southeastern states, is rarely found north of the Mason-Dixon line, and does not extend far into Texas from the east. It is a sturdily growing tree of large size, frequenting the swamps and lowlands. Over one-third of all veneer cut is produced from various members of the gum family.

Illustration 73. Rotary cut birch veneer, showing lighter color sap wood and the darker heart wood.
Courtesy, Underwood Veneer Co.

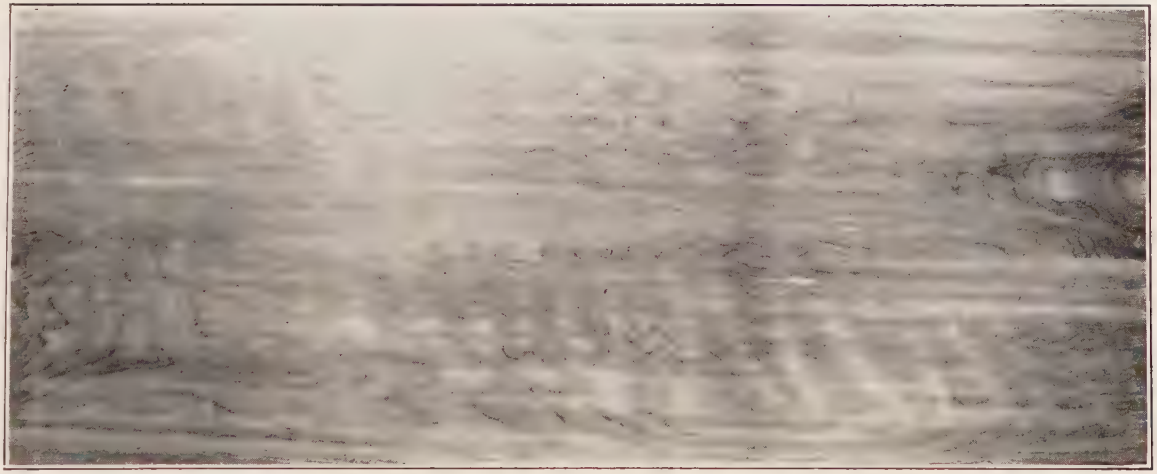

Illustration 74. Rotary cut curly birch.

Courtesy, Underwood Veneer Co.

While there are many varieties, the present commercial supply is cut largely from three well-known species, which are bought and sold under various trade names.

*Sweet gum* logs have a large brownish red heart with thin lighter colored sap. The heart wood is the ordinary red gum of commerce, and the clear sap, as well as the mixed heart and sap, is termed sap. The species is also called red gum and hence arises some confusion. This is the wood so generally used for furniture and interior trim, and so widely advertised by its proponents. Figured gum comes from occasional "freak" logs in this species. In Europe, this sweet gum is called either satin walnut or hazel, and is highly prized.

*Tupelo gum* has very little heart wood, and what there is resembles the sap so closely that they are rarely separated from each other in manufacture and sale. Tupelo is sometimes called bay poplar, because its appearance is so like the sap wood of yellow poplar.

*Black gum* is the third of the trio, and less known than the other two. It is usually included with the tupelo sapwood, of which, however, it is hardly the equal as a cabinet wood.

Gum is easy to work, and is extensively used for furniture and interior trim. Its reputation for warping has come mainly from those who did not understand its proper treatment in kiln drying, which, however, has now been satisfactorily developed. Low grade gum veneers are extensively used for box shooks and packing cases, either in single or 3-ply.

Gum takes an excellent finish in its own natural color, as well as in darker browns and reddish colors. Its frequent use as an imitation wood, particularly of mahogany and walnut, represents a period of indiscrimination that happily is now passing. Many users are more attracted by the delicate brownish red shades natural to the red gum, than by any substantial departure therefrom. Sap gum is frequently stained to match its own heart wood.

Figured gum veneers come mostly from unusual and freak

growths in the wood, and are usually sliced on the quarter to best show their figure. Illustrations 75 and 76 show red gum, as well as figured gum in matched figure. Some figured gum is sawed into quartered flitches and sliced.

## Maple

The *sugar maple,* source of the unequalled and unsurpassed syrup, is the hard or rock maple so generally used for flooring. It is found quite commonly in the northeastern portion of the United States. When grown alone or for shade purposes, it becomes too stocky for lumber or veneer, but in forest growth it attains large diameter and considerable height.

As a veneer wood, hard maple has little figure (see Illustration 77) except in the unique and somewhat mysterious bird's-eye growth. This miniature swirl grows radially, and when uniformly distributed in light colored wood, makes an attractive and decidedly valuable veneer. Occasionally, bird's-eye growths are found in walnut and some other woods. Bird's-eye maple (see Illustration 78) is rotary cut and needs speedy and careful drying to preserve the bright natural color in which this wood is usually finished.

Maple veneer, however, is the hardest and most dense of the common woods, and is sawed or rotary cut into 1/8, 3/16, 1/4 and sometimes 5/16 inch veneers to be glued up into 3-ply and 5-ply pin planks for pianos. The tapering pins which are used to maintain piano wire tension are set in this maple plywood, where obviously, only the hardest wood will serve.

Thinner maple veneer is used to some extent in furniture, where any plain wood will serve, and is also used for laminated insulating rings in electrical equipment.

*Soft maple* is less in volume than the hard variety, but is more widely distributed both in the South and the West. The scarce and elusive curly figure is found in the soft maple sap,

Illustration 75. Showing rotary cut red gum veneer, the heart of the sweet gum tree.

Courtesy, New Albany Veneering Co.

Illustration 76. Quarter sliced figured gum veneer, matched for decorative design.

Courtesy, Louisville Veneer Mills.

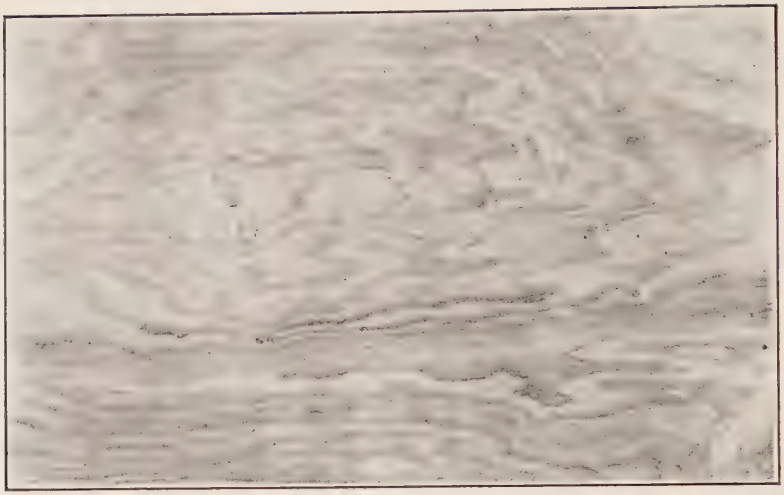

Illustration 77. Rotary cut maple veneer, from northern grown hard rock or sugar maple.

Courtesy, Wisconsin Veneer Co.

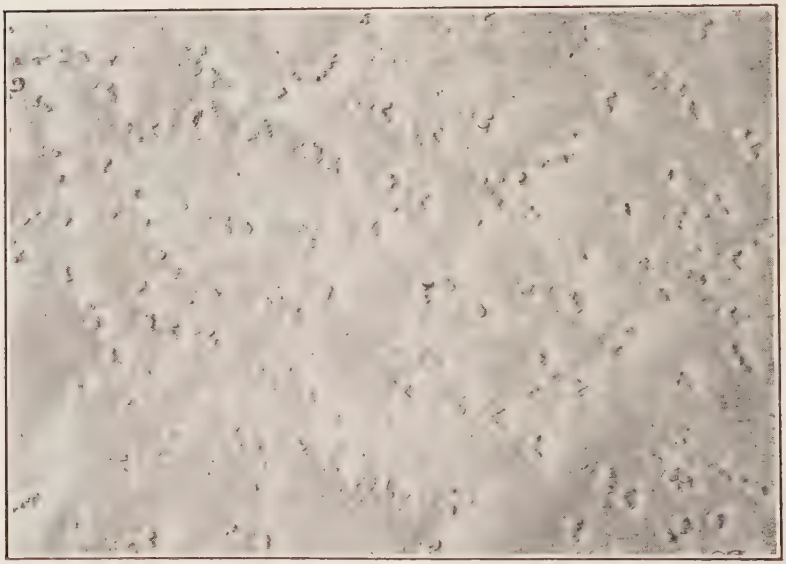

Illustration 78. Rotary cut bird's-eye maple veneer, showing a typical example of the unusual and attractive "eyes."

Courtesy, Bird's Eye Veneer Co.

and when uniform and clear for color produces some of the most valuable veneers. (See Illustration 79.) Otherwise the better grades of soft maple veneer are used for cross-banding, providing a harder foundation for soft face veneers than any other wood, and resulting in a surface that does not easily dent or deface.

## Poplar

This tree supplies, in its several species, the standard veneer for cross-bands. The tree grows everywhere and attains commercial size in fewer years than many other woods.

The color of the veneer varies from a cloudy white to a yellowish brown and is ordinarily produced for use as cross-banding in the production of the higher grades of plywood.

Occasionally there is discovered a poplar tree of a freak growth from which a blistered poplar veneer may be produced. This blistered veneer is highly prized and is of considerable value as an appliqué or overlay veneer.

Rotary cut poplar veneer, as customarily produced, can be cut without cooking, dries quickly without checks or wrinkles, makes strong glue joints and is plentiful enough to be reasonable in price.

Poplar veneer, sliced to reduce surface checking and loose cutting, is frequently used for bending into grand piano rims, faced inside and outside with mahogany, walnut, rosewood, ebony or other face wood.

Poplar lumber is a favorite for plywood cores, because of the same excellent gluing qualities, as well as due to its easy working qualities, flatness and freedom from checks.

## Ash

*White ash* is essentially a wood of strength and toughness like hickory. *Brown ash,* from which veneer is usually produced, does not have the strength and toughness of white ash,

but is more desirable for cutting into veneers, because of the ostentatious appearance of the grain character, which properly balanced and matched, makes a very prominent showing and is often used for showcases and show window panel trim, and in wainscoting where wild unusual character or grain effects are desirable. The veneer is usually produced by rotary cutting and is shown in Illustration 80.

History shows that ash was known to the ancient Romans and by them used as a veneer.

Ash burls are protruding growths, with closely twisted and interlaced figure, and are used chiefly for appliqués or overlays.

### Elm

Elm has been the veneer wood of the basket, barrel and hoop makers, where toughness was the one and only essential. The lower grade of elm logs, growing in the lowlands, cannot be used for much else than the above.

Gray elm (species white or American elm), however, makes a pleasing veneer surface for interior trim, not unlike the ash in appearance. A gray elm panel is shown in Illustration 81.

Elm veneer, because of its toughness, is also used as a wrapper for leather. When rolled into cylinders, it affords excellent protection in keeping hides from creasing or denting.

### Beech

This is one of the harder woods related to the oaks usually found growing with birch and maple. Its use as a veneer is largely confined to baskets and shooks.

### Sycamore

This is the plane tree of ancient history, although European and American species differ somewhat.

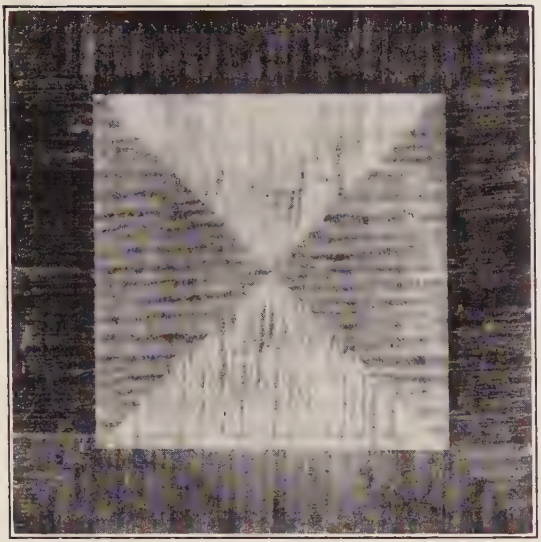

Illustration 79. Curly soft maple veneer, rotary cut, diamond-matched in panel, with rosewood border.

Courtesy, Luce Furniture Co.

Illustration 80. Showing the wide variety of grain in rotary cut brown ash.

Courtesy, Underwood Veneer Co.

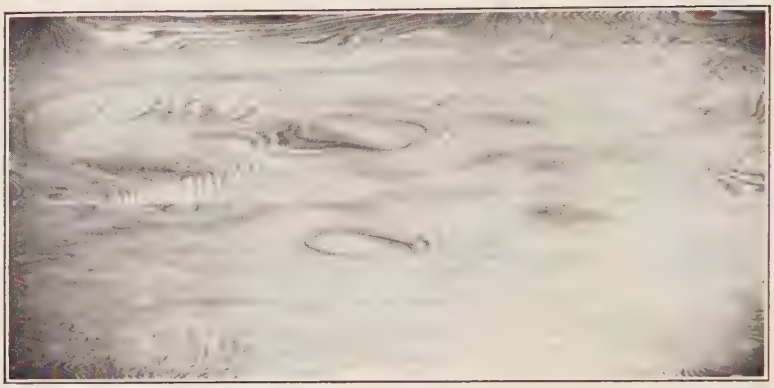

Illustration 81. Showing several sheets of rotary cut gray elm, joined together.

Courtesy, Underwood Veneer Co.

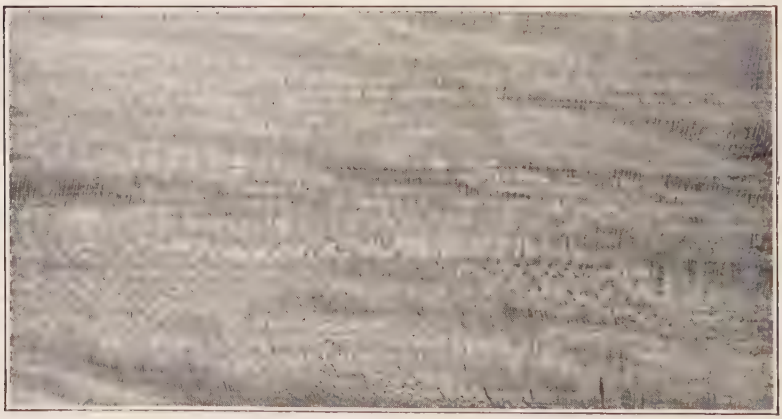

Illustration 82. Showing the flake grain of quartered sycamore, used largely for drawer interiors.

Courtesy, Luce Furniture Co.

The scaly bark of this tree makes it easy to identify anywhere. Its lumber when quarter sawed is in considerable demand for use as drawer sides. Quarter sawed or sliced sycamore veneer has a small flake or splash effect, quite uniform in distribution, that makes it popular for plywood drawer bottoms in furniture, as shown in Illustration 82. It is nearly as hard and dense as hard maple.

## Cherry

Cherry is an unusually close-grained wood of a pinkish color, not often used for veneer, although it possesses strength and hardness.

Cherry was used in the 19th Century for furniture, particularly school equipment in New England, and was known for its color rather than its grain figure.

## Basswood

Basswood is a quick growing tree with soft fibrous texture and is lacking in strength. It is light, easily cut cold on the lathe, and holds glue admirably. The rotary cut veneers are best suited for cores and for cross-banding.

Basswood has been a favorite veneer for use in trunk making, both in single and multiple ply, since it is one of the lightest woods in weight, and when glued into plywood readily takes concave or convex shapes for tops of trunks, musical instrument cases, and the like. The growing scarcity of basswood has lessened its use in this industry, and both gum and poplar are taking its place.

The bellows, or pumpers, of player pianos are frequently made from bass plywood, since it is easy to bore, cloth can be firmly glued to it, and it holds its shape.

There is no figure and little finishing quality to basswood veneer.

### Cottonwood

This is a rapidly growing tree usually found in the western and southern lowlands and river bottoms. Its veneer is not particularly strong, has no figure, and is used mostly for box shooks; the better grades, when rotary cut, can be used for veneer cores.

### Pine

The softwoods, from the coniferous or needle-leaved trees, have been and still are, the principal construction woods for dwellings and the like, and have become a large factor in the production of interior trim.

Pine veneer and plywood are chiefly used in the making of doors, cabinets, paneling and the like. There is no figure in pine, but considerable grain character is obtained by rotary cutting and this is similar in markings to the rotary veneers of the hardwoods, except that the alternate summer and winter growth rings in pines are much more pronounced, and therefore the character is emphasized by broader grain lines.

This large conspicuous grain may be centered in doors, wainscoting and ceiling panels, and finished in the various shades of browns and reds.

Occasionally pine logs are found with curly grain that relieves the monotony of the usual conventional characteristics.

Some of the species of pine which are light in weight are used in the trunk trades, displacing the traditional basswood.

It is also finding a place in the furniture trades for drawer bottoms, backs and partitions, as well as for bellows in player piano construction.

### Douglas Fir

Douglas fir is one of the leading timber trees of America, its annual cut in 1923 (the latest available Government report) being second only to the yellow pine. The botanical

range of this tree extends over a vast area, reaching from Canada to Mexico, in that portion of the United States west of the eastern foothills of the Rocky Mountains, but it is in western Washington and western Oregon that Douglas fir assumes the so-called "coast" form. Here is what is known as the "Douglas Fir Region," where Douglas fir reaches such enormous dimensions that trees from 60 to 90 inches in diameter and from 200 to 250 feet in height are common.

Wood cut from these large Pacific Coast trees is even in texture and has attractive grain characteristics and unusual strength. It is worthy of note that Douglas fir produces the strongest wood in proportion to its weight of any of the commercial softwoods that are available in large quantities. (See Illustration 83.)

Botanically, Douglas fir is not a pine, yet because it possesses the characteristics of pine it has been sold in foreign markets since the first sawmill was established, as "Oregon pine." It is not a spruce, yet it was originally called "Douglas spruce," for it is tough, strong and elastic, and in these respects resembles spruce. It is not a fir, but because of its low resin content it does somewhat resemble the wood of a fir tree.

Douglas fir belongs to a distinct genus, and in this genus it is the only important timber tree; it is not a pine, a spruce, nor a fir, yet it combines the good qualities of these three important timber trees.

The wood produced from Douglas fir is resistant to decay, comparing favorably in this respect with white oak. Logs that have been buried in the debris of the forest for half a century or more are often cut into lumber that is sound and unblemished. Staining of the lumber in the mill yards is unknown. Even when green Douglas fir is loaded into the holds of vessels which must pass through the tropics, the inevitable mildew that forms is entirely superficial, and when the lumber is finally surfaced, it emerges as bright and sound as the day when it was shipped.

Douglas fir veneer is largely used in the manufacture of 3-ply door panels. One of the popular and well-known makes of doors on the market today is made with built-up rails and stiles, which rails, stiles and panels are covered with rotary cut, edge-grain Douglas fir veneer, glued with water resistant casein glue. The edge-grain veneer is cut on the stay-log lathes previously described.

Douglas fir plywood is used extensively for interior panelling, as well as for linings, backing, drawer bottoms and all work where light weight, strength and freedom from warping and shrinking are demanded. It is also suitable for the manufacture of trunks and cases.

## Cedar

The popular conception of the term sanctions its use not only for the traditional and Biblical Cedar of Lebanon, but also for the cedar of shingles, the familiar lead pencil, the aromatic Virginia cedar, with its alleged mothproof qualities, and the Spanish cedar so extensively used for cigar-box veneer.

The *aromatic cedar* is used as a sawed veneer for the lining of cedar chests, where the exterior is veneered with walnut, mahogany, or some other wood to match furniture suites. Cedar logs are too small to make veneers by any other process than sawing, and then they must be sawed through and through; rotary cutting or slicing would shatter the wood and loosen the knots. The solid cedar chest was difficult to finish in pleasing and harmonious colors, knots (the largest depositary of the aroma) would drop out or check, and the solid wood was likely to cause trouble from cracking and warping.

The *Spanish cedar,* one of the "near" mahoganies, and usually growing in the same tropical districts, is a tree of large size, making wonderfully large sheets of sliced veneer, used almost exclusively for cigar-boxes, either in plywood or solid 1/8 inch thickness. It is occasionally used for drawer bottom

Illustration 83. Showing the typical grain of rotary cut Douglas fir.

Courtesy, Wheeler-Osgood Co.

Illustration 84. Showing Brazilian rosewood, four-piece matched. Much of the rosewood used is the plainer stripe, similar to the outer corners of the illustration.

Courtesy, New Albany Veneering Co.

and mirror back grades in furniture. It should, however, never be classified as a true mahogany.

### Cypress

This is one of the few woods whose identity has come down through the ages; it is the gopher wood of which Noah's Ark was said to have been built, the wood of which surviving mummy cases are found to have been made, the timber from which the Romans invariably made their crosses for crucifixions, and it is the traditional, as well as the present wood, from which burial caskets have been made for the long lineage of the Popes of the Roman Catholic Church.

Its peculiar lasting qualities are well recognized, but it is not often used for veneer, and has little figure or character.

### Spruce

Veneers from clear spruce were used to some extent in airplane construction, because of the usual combination of light weight and strength.

### Redwood

Redwood has the peculiar burl growth that provides extraordinary twisted veneer figure that is so well adapted to onlays and overlays, but is rarely used otherwise as a veneer.

### Fancy and Figured Woods

The list here presented might be extended indefinitely, as many veneer woods have run the gamut of use and popularity, and dropped out of sight entirely. The various woods described are those most frequently found in modern and historic furniture, showing the relationship, if any, to the better

known woods. Much of the information has been abridged from G. S. Boulger's book, "Wood—a manual of the natural history and the industrial applications of the timbers of commerce." [1] The ancient art of inlaying and marquetry included not only wood, but ivory, precious metals, jewels and the like.

Acacia. This is a tree similar to the modern locust, usually called acacia in England and British colonies. It has narrow sap wood and vari-colored heart wood, ranging from yellowish brown into shades of red and green. The wood is heavy and tough and was used somewhat in early inlays.

Amboyna-wood. The burls of this tree are fragrant, light reddish brown to orange in color, very hard and beautifully mottled and curled, take a good polish and are very durable. It grows in the East Indies and is used only as an inlay.

Box-wood. This is a close, hard-textured wood, the only American tree varieties growing on the Florida keys. It is a wood of commerce in the West Indies, exported mostly to England. It is not hardy and grows in the central section of the United States only as a shrub. It is used chiefly for wood type, skewers, toothpicks and other products requiring density and toughness. As a veneer its only use is for inlaid work when its peculiar yellow shade is desirable.

History tells of binding boxwood trees in Italy with iron bands. The wood, growing out between the bands, throws out many shoots, which are pruned, and the final result is a combination of curly and burly figure. The Japanese also practice the art of artificially forcing the development of figure in wood.

Ebony. The ebony of history, mentioned by Herodotus and probably by Ezekiel, grows in southern India and Ceylon. The sap wood is a dingy gray, while the heart wood is deep black in color, very heavy, hard, fine grained, and capable of

[1] "Wood," by G. S. Boulger. Published by Edwin Arnold, London, 1902.

taking a very high polish. It is used as a veneer for inlays and even for entire surfaces of plywood. The best known use for the solid wood is that of piano keys.

There are two so-called American species, one the Texan ebony, of the locust family, prized as a shade tree, but having a texture like the imported ebonies. The American persimmon tree, with exceedingly hard wood, is also of the ebony family.

The West Indian ebony is used largely for the making of flutes and wood wind instruments. There are many other ebonies, less known, ranging from the red ebony of Mauritius and the purple ebony of India to the white ebony of the Philippines.

Holly. This is a wood that grows all over the world, but only four species of tree are found in America. Wreaths of holly twigs were used as tokens of good will before the Christian era. The best American example of this wood grows in Texas. The woods of European and American holly are quite similar in appearance, and resemble ivory in color and texture. It is a very hard wood, used for engravers' blocks, walking sticks and veneer inlays. The terms ilex and holm-oak are sometimes used to refer to this wood.

Laburnum. The Corsican ebony of Ancient Rome was used by the ancients as a veneer, but is not a true ebony. The sap wood is yellowish, and the heart wood dark brown with a greenish tinge. It has distinct rings and pith rays, taking a high polish, but is not strong nor durable.

Lotos-wood. This is said to have been used in Greek sculpture, and was probably the nettle tree, still used in southern Europe. This wood when cut obliquely resembles satinwood. It is similar to the American hackberry.

Olive. This is a tree originally growing in the Mediterranean regions which was cultivated principally for its fruit.

It is related to the family of ash trees. It was frequently mentioned in Bible times. It is a low growing tree, seldom more than 20 feet high. The wood is very close and fine grained, light yellowish brown in color, with irregular wavy dark lines and mottlings, especially near the root, resembles boxwood in texture, takes an excellent polish, and has no distinguishable rings or pith rays. It is largely used in early examples of inlays and marquetry. There are also similar species known in southern Africa and India.

Plane. This is the European sycamore, closely allied to the American species, and its use for veneer inlays dates from antiquity.

Purple-heart. This is a tree growing in Trinidad, yielding a wood of beautiful purple color when freshly cut, but blackening with age. It is very durable but its changeable color restricts its use for veneers and inlays.

Rosewood. This is named from the odor of its fragrant resin or oil, but it has no further connection with roses. The commercial supply of logs, from which rosewood veneers are cut, comes from Brazil. The tree seldom yields logs larger than 14 inches in diameter. The wood is dark chestnut or ruddy brown, richly streaked and grained with black resinous layers (see Illustrations 79 and 84), porous, open-grained, heavy, takes a fine polish, but is liable to heart shake.

Saffron-wood. This grows in South Africa and is hard, close-grained and tough but with handsome figure. It is used somewhat in veneers and furniture.

Sandalwood. This fragrant wood comes chiefly from southern India, the fragrance increasing with age. The wood is very hard, yellowish brown in color, close-grained, but liable to heart shake. Its diameter runs up to 2 feet and it is sold in billets by weight. It is used largely for carving, ornamental

boxes, walking sticks and fans, the veneers being extensively used for inlays.

SATINWOOD. This is an imported wood coming from Australia, India and the West Indies. It makes a light orange-colored wood with beautifully feathered figure, is heavy, hard, close-grained and takes an excellent polish. It is likely to darken with age as does mahogany. The more beautiful feathered wood (see Illustration 85) is used for veneer inlays, brush backs and cabinet work.

> A wagon load of satinwood, worth $75,000, was delivered to an English furniture manufactory recently. It was cut for veneer work, sixteen thin sheets to the inch. The price paid per square foot was one pound sterling.[2]

TEAK. This is an oriental tree, with fragrance similar to rosewood, and largely used for chests, as its odor repels most insect pests. It is somewhat similar to oak in working qualities. It is not used much for veneer nor inlays.

TEREBINTH. This is a Syrian tree, used for inlays in ancient times.

TULIP-WOOD. This is not to be confused with the tulip tree or poplar. Tulip-wood from Brazil is a rose colored, beautiful striped wood used for inlaying.

WHITEWOOD. (American or Canary) This usually refers to the tulip tree. The wood is similar to and often confused with the poplars, but the true tulip tree is heavier and more valuable both as lumber and veneer.

YEW. This tree, known to the ancients, has wood of a reddish brown color, resembling mahogany, hard, close-grained and elastic, susceptible of a high polish, insect proof, and more durable than any other European wood. In the latter

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[2] "The Tree Book," by Julia Ellen Rogers. Published by Doubleday, Page & Co., Garden City, N. Y., 1914, p. 527.

part of the 18th Century, yew trees were extensively used for veneers and inlays on tea caddies and other small articles.

The Japanese yew is a lighter wood used both for cabinet work and for lead pencils (like American cedar).

Zebra-wood. This is a reddish brown wood, growing in British Guiana, locally known as "Hyawaballi." It is a beautifully marked striped wood (See Illustrations 86*a* and *b*), works well and takes a good polish, but is very rare.

## Botanical Classification

For the benefit of those who wish to use more technical designations, the following list has been prepared. No claim is made for completeness, since many "near" species are commercially grouped with similar appearing woods. Some of the chief families having many ramifications are the gum, mahogany, oak and pine.

There are many excellent and comprehensive publications fully covering this subject, to which students of accurate classification are referred.

The various species mentioned in this chapter by their common names, are arranged in the same order in the following list of botanical names:

a. Walnut, European (Juglans regia)
   Walnut, black (Juglans nigra)
   Walnut, white or butternut (Juglans cinerea)
b. Mahogany (Swietenia mahagoni)
c. Oak, white (Quercus alba)
   Oak, red (Quercus rubra)
   Oak, English (Quercus robur)
d. Birch, yellow (Betula lutea)
   Birch, red (Betula nigra)
   Birch, American white (Betula alba)
e. Gum, sweet (Liquidambar styraciflua)
   Gum, sour, black, Tupelo (Nyssa sylvatica)

Illustration 85. Showing the fine feathery figure of satinwood, four-piece matched. One of the figured veneer woods that has been used for many centuries.

Courtesy, New Albany Veneering Co.

Illustration 86*a*. Zebra-wood, arranged in diagonal stripes.

Courtesy, Luce Furniture Co.

Illustration 86*b*. Zebra-wood, matched in four pieces, giving a diamond pattern. Colors are in sharp contrast.

Courtesy, New Albany Veneering Co.

f. Maple (originally, Acer campestre)
Maple, hard, rock, or sugar (Acer barbatum or saccharum)
Maple, soft, red (Acer rubrum)

g. Poplar, black (Populus nigra)
Poplar, Carolina (Populus moniliferd)
Poplar, white (Populus alba)

h. Ash, white (Fraxinus americana)
Ash, red (Fraxinus pennsylvanica)
Ash, black (Fraxinus nigra)

i. Elm, English (Ulmus campestris)
Elm, white or American (Ulmus americana)

j. Beech (Fagus americana)

k. Sycamore maple or plane-tree (Acer pseudo-platanus)

l. Cherry, black, rum (Prunus serotina)

m. Basswood or linden (Tilia americana)

n. Cottonwood (Populus sargentii)

o. Pines
Western white (Pinus monticola)
Northern white or soft (Pinus strobus)
Northern or Scotch (Pinus sylvestris)
Short-leaf (Pinus echinata)

p. Douglas spruce, red fir (Pseudotsuga Douglasii or pseudotsuga mucronata)

q. Cedar, American or northern red (Junipedus Virginiana)
Cedar, Spanish (Cedrela odorata)
Cedar of Lebanon (Cedrus libani)

r. Cypress (Cupressus sempervirens)

s. Spruce, white (Picea alba)

t. California redwood (Sequoia sempervirens)

u. Fancy and Figured Woods
Algiers acacia (Melanoxylon acacia)
English acacia or locust tree (Robinia pseudacacia)
Amboyna-wood (Pterocarpus indicus)
Boxwood (Buxus sempervirens)
Ebony of Ceylon and East Indies (Diospyros ebenum)
Ebony of Texas (Diospyros texana)
American persimmon (Diospyros virginiana)
Elder (Sambucus nigra)
Alder (Alnus glutinosa)

Holly (Ilex aquifolium)
Laburnum or false ebony (Cytisus laburnum)
Lotos-wood or nettle tree (Celtis australis)
Olive (Olea europaea)
Plane
  Eastern or oriental (Platanus orientalis)
  Western or occidental (Platanus occidentalis)
Purple-heart of Trinidad (Peltogyne paniculata)
Rosewood or blackwood (Dalbergia latifolia)
Saffronwood or umbomoana (Elaeodendron croceum)
Sandalwood (Santalum album)
Satinwood (Chloroxylon swietenia)
Teak (Tectona grandis)
Terebinth, Syrian (Pistacia terebinthus)
Tulip-wood, Brazil (Physocalymma floribunda)
Whitewood, or tulip tree (Liriodendron tulipiferd)
Yew (Taxus baccata)
Zebra-wood (Connarus guianensis)

# CHAPTER XIX

## MODERN VENEER CUTTING MILLS

Now that the history of veneer and the technical details of its production and identification have been outlined in an orderly and systematic manner, the opportunity is presented to wander leisurely through a few typical veneer cutting mills and to observe some most interesting and fascinating details at first hand.

### How Logs are Sorted and Stored

Logs suitable for cutting into veneers are not nearly as plentiful as is popularly believed. They must be straight, sound and clear. Logs less than 15 inches in diameter, at the small end, are rarely suitable for rotary veneer, since some wood is always lost in truing up the log. From 6 to 7 inches in the center of a log cannot be cut at all. For slicing and segment sawing, logs should be 18 inches and up, to allow for "flitching" or opening up. The "back" board on a slicer or saw, required for mounting, prevents cutting the last inch or so.

Logs smaller than the above, or having apparent defects, as well as crooked and unsound logs, are culled out and are suitable only for the sawmill. It is important that veneer logs be sorted out, because of their higher value, and that no logs be sawn into lumber that might produce good veneer.

Log yards and log ponds are stocked seasonally, when climatic conditions permit, or the necessary labor is available, or the price favorable, and other controlling conditions do not

prevent. In the northern states, winter weather favors economical logging; and in the southern states, the wet season (corresponding to northern winter) may absolutely put a stop to all logging. Logs from a farmer's woodlots cannot be bought when the farmer is busy with his crops, but only when other work is not pressing and he can obtain ready cash for good logs.

Hot weather will check the ends of logs if unprotected from the sun. Warm foggy weather will encourage mildew and various fungus diseases leading to decay. Most logs are more safely stored under water in ponds. Oak logs, however, must be kept out of the water, as must other woods in which discoloration becomes a defect.

Several illustrations (87 to 90) show well-stocked log yards and ponds.

The handling of logs at the mill is usually by means of cranes or derricks, although a good crew of lumberjacks will handle an amazing amount of logs without any mechanical aids.

## Sawing Oak Veneer

The first trip will be to observe the making of quarter sawed oak veneer, as well as the other products that are made on the same types of machinery.

Log Selection. White and red oak are both used for veneers but, in the world consumption, ninety per cent of the quartered oak veneer comes from white oak logs. Trees on thin limestone clay soil or on hilltops grow more slowly, producing narrower yearly growth rings than the same species growing in fertile lowlands, where the yearly growth rings are two, three or four times as great. This slow growth oak produces the small grain (not flake) soft textured, most desirable cabinet oak, both for veneers and for lumber.

Illustration 87. Michigan logs decked up in a pond. The floating logs in the foreground are ready to be taken up the chain to the drag-saw, from which location the photograph is taken.

Courtesy, Grand Rapids Veneer Works.

Illustration 88. Showing northern logs, some decked up for storage and some spread out for easy access.

Courtesy, Underwood Veneer Co.

Illustration 89. Corner of log yard, decked up for storage.
Courtesy, Bird's Eye Veneer Co.

Illustration 90. Mahogany logs stored in and out of tidewater. Winter scene of log pond in foreground with piles at left, right and rear center.
Courtesy, Ichabod T. Williams & Sons.

The first step in producing quartered oak veneer is to select logs which are tight hearted, clean and free of defects, as well as 24 inches and up in diameter. These logs should be promptly sawn into veneer flitches and veneer, for as the log grows older it becomes checked, dries out and will not produce veneer of the best quality.

Flitching. The freshly cut log is taken into the sawmill where it is split and "flitches" (6 inches and up wide) are sawed by one of the methods shown in Illustration 91. Il-

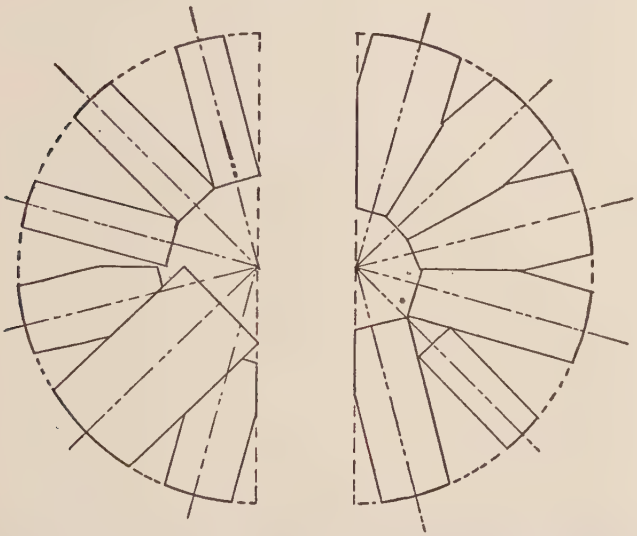

Illustration 91. Methods of flitching logs preparatory to quarter sawing veneer. Each method has ardent advocates, but the decision should rest on the character of log to be flitched.

lustrations 92 and 93, respectively, are glimpses of an Ohio Valley mill, showing flitches being sawed on a bandmill, and also showing a segment saw producing quartered oak veneers.

In cutting logs into flitches, care must be exercised so that the medullary ray, from the center of the log, runs parallel to the sides of the flitch. This ray forms a sunburst in the log,

extending out from the heart, and the best figure or flake is produced when the sawing parallels this ray. As the saw leaves the true path of the ray, the figure gradually becomes less pronounced. These flitches are now ready either for sawing (or slicing) into veneers.

The sheets of quarter sawed veneer are produced by taking fresh cut flitches direct to large, accurately built circular saws with segmental teeth. The flitch is clamped to a carriage by edge "dogs" with the better quartered face exposed to the saw. It is then sawed into the required thickness. A large majority of the cabinet-makers use 1/20 inch sawed quartered oak veneer. Door, house trim and interior finish may require other thicknesses, of 1/16, 1/8, and occasionally 1/4 inch.

Veneer Sawing. As the veneer is sawed into sheets 1/20 inch thick, the saw kerf about equals the veneer sheet. In other words, the saw takes out more than 1/20 inch in sawdust. The saw must be set to make a smooth cut, for one "wild" tooth in the big saw would damage the veneer for later use.

The sheets dropping from the flitch must be kept in sequence and it is standard practice to number them so that their relative position cannot be lost. The veneer should be dried immediately to prevent discoloration. There are several drying methods used in regular commercial practice in the United States. The older way is to set on edge in racks in a room with forced air current for drying. The more modern way is to pass veneers in sheets through mechanical dryers, either roller, belt or platen type, which are more fully described in Chapter XX.

Preparation for Market. The veneers when dried, are reassembled into their original flitch form and measured. The customary way of measuring is to turn two sheets at a time and measure with tape from edge to edge, later computing the

Illustration 92. Showing the production of quartered white oak flitches. Note the thin light colored sap and the relatively large proportion of heart wood.

Courtesy Wood-Mosaic Co.

Illustration 93. Showing the sawing of quartered white oak veneer on segment saws. Usually cut to 1/20-inch thickness.

Courtesy, Wood-Mosaic Co.

Illustration 94. Showing segment saw, producing thin maple lumber for piano rims and pin blocks.

Courtesy, Fuller-Thurber Co

total footage. The final markings on the flitch should show the length, the average width, as well as the total width by the tape line, the total footage and the number of sheets in the bundle. This is usually written on the top sheet of the flitch, which is then ready for inspection and shipment.

Quartered oak veneer is usually offered "6 inches and up wide." It will run at least eighty per cent, 6 to 10 inches wide; twenty per cent, 10 to 15 inches wide; occasionally wider.

Other Segment Sawing. While segment sawing is more often used in producing quarter sawed oak than in any other line, yet the same equipment is used in making 1/8, 3/16, 1/4, and sometimes 5/16 inch thickness sawed maple (quartered or plain) for piano wrest plank. (See Illustration 94.) There is some demand for thin, plain (not quartered) oak, birch, maple, and beech for special interior trim and door work. There are other industrial uses for thin lumber, in which the segment saw is used, since it only wastes 1/16 inch in saw kerf while most resaws will waste twice as much, and will not run as true to thickness as a segment saw.

## Steaming or Cooking Logs

Nearly all varieties of veneer logs are steamed or cooked in hot water to soften the texture, so that they may be cut on slicer or lathe with a minimum of tearing and breaking. Hot logs, direct from vats, are preferred for easy cutting. Manufacturers do not agree as to whether cooking in vats or steaming in closed chambers is most desirable. The necessary time of steaming is measured in hours, while cooking is a matter of days, depending on hardness of wood and size of logs. Some kinds of logs, like basswood, are cut "cold," i.e., as they come from the woods. Logs to be sawn, such as oak, do not need cooking or steaming, since there is little danger of tearing and negligible surface checking in obtaining cutting clear-

ances. Vats have always been expensive to maintain and decidedly dangerous, but no satisfactory substitute has been discovered. Either cooking or steaming makes the bark easy to remove.

There has been some controversy as to whether veneer from cooked or steamed logs shrinks most in drying. The tests so far made at the Forest Products Laboratory show no appreciable variation.

## Slicing Mahogany Veneer

The next trip will be to the Atlantic seaboard, as most mahogany mills are located on tidewater.

The Rough Logs. The mahogany log has done much traveling from the time it left the stump in Africa or in Central America, or perhaps in the northern border of South America or in the West Indian isles, until it arrived in the United States. The African logs are usually hewn approximately square (see Illustration 95), but are so many months in transit—by "man-power" over land, through creeks and rivers, thence by raft to cargo steamers which bring them to destination—that their beauty and character are usually well concealed by the marks of many rough handlings. The logs from Central and South America are usually round and unhewn, with much of the bark removed in handling (although logs are sometimes "barked" in the woods when felled to decrease "worming" and to save freight and steamer space), but withal, no more revealing their hidden beauties than the African logs.

Upon arrival at a seaport in America, the mahogany logs are sometimes stacked up in huge piles for early sawing into flitches, but more frequently they are left in log booms in the water to prevent deterioration by the sun. (See Illustration 96.) Cargoes sometimes contain in addition to mahogany, minor quantities of various other valuable cabinet woods and

Illustration 95. Square mahogany logs in Africa.
Courtesy, Ichabod T. Williams & Sons.

Illustration 96. Showing mahogany logs, some in piles on land, others in log pond; chain and derrick to mill are in foreground and logs are being unloaded from steamer in background.
Courtesy, Ichabod T. Williams & Sons.

Illustration 97. Showing a square-hewn African mahogany log just opened up for inspection and flitching.

Courtesy, Ichabod T. Williams & Sons.

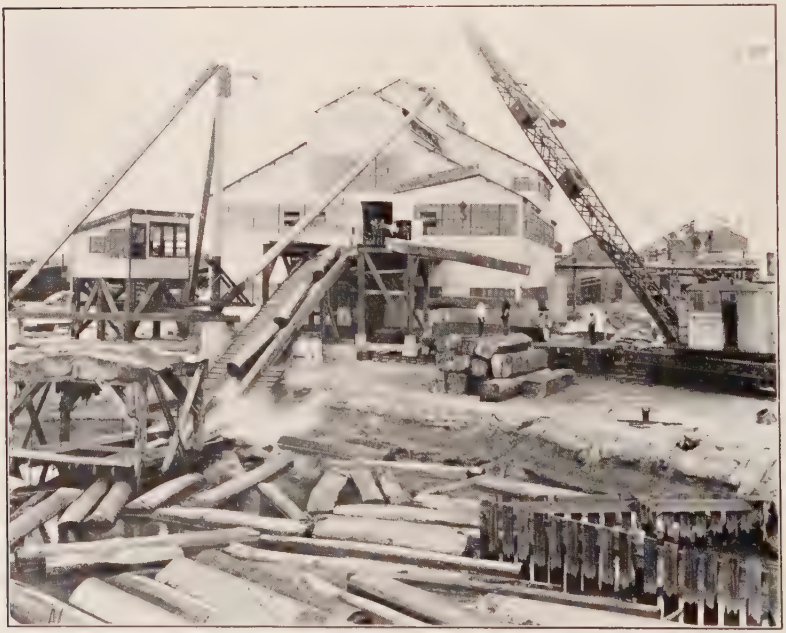

Illustration 98. Showing three ways of transferring logs to mill: from log boom by log haul-up chains; stiff-leg derrick, transferring from water, piles, or railroad car; locomotive crane handling from water, pile, or car.

Courtesy, Ichabod T. Williams & Sons.

frequently in the Central American cargoes, quantities of Spanish cedar are included, this wood being used principally for making cigar-boxes.

Flitching. The first marked surprise for the uninitiated observer, after his recovery from viewing the enormous piles of weathered mahogany logs as well as those floating in the boom (many millions of feet in all), is the wonderful color display of mahogany, uncovered as the bandsaw goes through the logs, the slabs drop off, and the log is divided into "flitches," as shown in Illustration 97. Any shade of red may be found from the creamy salmon pinks to the deep sherry but only a few logs have enough "figure" to be really valuable. The mill superintendent and the sawyers are ever watchful to find the sound log of rich color and beautiful figure. When such fine logs open to view, unusual skill and experience is required to saw them into such flitches as will produce the handsomest veneer. A log, especially the large hewn log from Africa, will sometimes produce from four to twelve magnificent flitches. Every saw-cut is painstakingly made to preserve flitch size and figure, and all slabs and boards are carefully saved so that no real figured mahogany may be lost. Mahogany flitching requires much experience and experts are exceedingly scarce.

In the big New Jersey mill under observation, the saw-deck has three bandmills—the first two saws are used for "opening" and roughing out flitches for the slicers and segment veneer saws. The center unit is used to saw into lumber, cants or flitches not suitable for veneer. The three ways in which logs can be handled into the mill are shown in Illustration 98. As much as one hundred thousand board-feet of mahogany logs are sometimes cut by these saws in a single day, this depending upon the size and character of the logs. The production of mahogany veneer is by no means the only function of this mill, since other foreign and domestic woods are also cut and sawed. Many logs that will not produce veneer are sawed into lumber;

however, the amount and quality of mahogany veneer is the measure of successful operation.

Slicing the Flitch. The flitch as it comes from the bandmill is clean, sound, and reasonably free of defects. The rough, irregular or split ends are then cut off using a "drag-saw" and the flitch is put into the steaming or boiling vats where it is both heated and softened in preparation for the slicers. Slicing cold without steaming is impossible with a wood as hard as mahogany; too much heat produces a roughness in the cutting which is undesirable.

The slicers are massive upright machines, shown in Illustration 99. The largest slicer (shown in the background) is some 12 feet high, with a movable bed, equipped with "dogs," which will take a flitch as large as 24 by 30 inches, and up to 17 feet long. The bed, with flitch clamped thereon, is moved up and down, on diagonal guides, by means of two crank shafts, giving a "shear cut"; while the knife bar is fed in, between strokes, a distance equivalent to the thickness of a sheet of veneer, usually 1/28 inch, but sometimes 1/24 inch, and for special requirements 1/20 or even 1/16 inch may be made. The grinding and sharpening as well as adjustment of the cutting knife and pressure bar, is an operation requiring much skill and experience. Properly mounting the flitch on the cutting machine requires extensive knowledge of the character and grain of the wood. Often a flitch has to be "turned" and remounted several times before the cutting is complete, or until the foreman is satisfied that the flitch is yielding its best and is cutting smoothly.

The best stripe (or mottle) figure comes from a pure quartering (radial), but ripples, blister and other surface figures sometimes show to best advantage when cut across the radius. The dropping sheets of veneer from the cutting machine are a most fascinating sight to the lover of beautiful woods. Mottles, fiddle-back and other waviness resulting from irregular

Illustration 99. Showing two veneer slicers, the larger in the background. The logs are moved up and down against a knife, while the sheets of veneer drop off behind the knife and are piled on the trucks as shown. Additional flitches are shown suspended from derricks above.

Courtesy, Ichabod T. Williams & Sons.

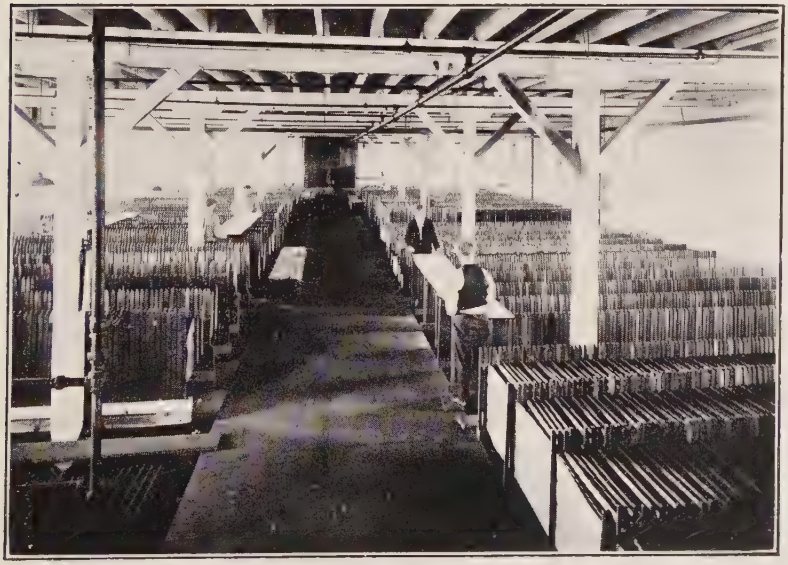

Illustration 100. Showing loft drying of mahogany veneer in finger racks.

Courtesy, Ichabod T. Williams & Sons.

Illustration 101. Measuring and sampling mahogany veneer, with labelled warehouse piles in background.

Courtesy, Ichabod T. Williams & Sons.

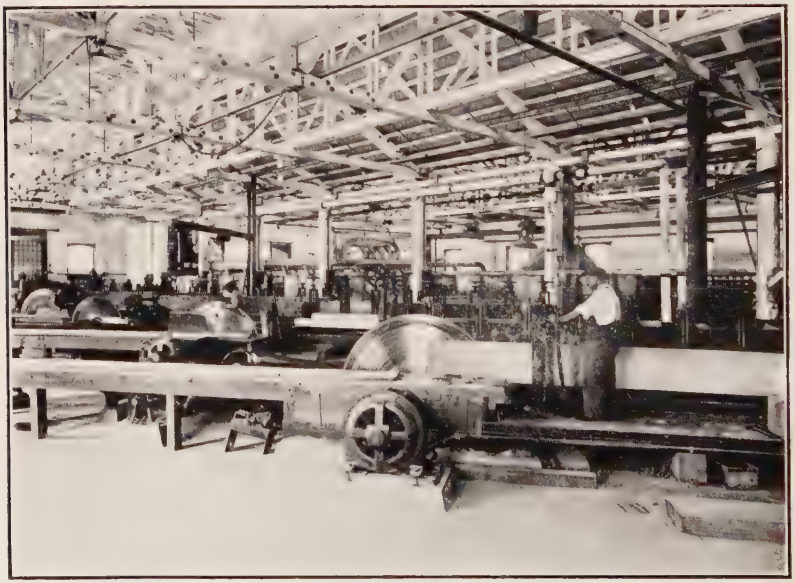

Illustration 102. Showing a battery of four segment saws, with veneer roller dryer in rear. Note that saws are set diagonally (motor driven) to economize floor space.

Courtesy, Ichabod T. Williams & Sons

growths and from interwoven grain, all vary with more or less irregularity and the result is not unlike the shadows cast in a field of wheat or of oats waving in the breezes. One never tires of watching the ever-changing delicate tints and colors of the dropping sheets of veneer, and one marvels at the entrancing variety of beautiful figures and shadings.

Drying, Scaling and Sampling. Sliced veneer is always kept in flitches, with sheets laid in sequence. From the slicer the veneer is taken to a drying loft or to an artificial dryer where the moisture content is reduced to between ten and fifteen per cent,—not so dry as to be brittle but just dry enough not to mould or mildew. Most manufacturers redry these veneers before using. In a drying loft (and many manufacturers and users of veneer still advocate drying under such conditions), the sheets of veneer are placed on edge between upright supports, called "finger-racks." (See Illustration 100.) Two or three sheets are usually placed in each opening and the whole room subjected to several interchanges per hour of moist heated air. On removal from racks, the veneer is replaced in sequence, carefully measured with a tape for aggregate width, marked with flitch and log numbers and the footage. Samples are removed from top, center, and bottom of the flitch and the stock then sent to the warehouse for storage until sold. Illustration 101 shows the measuring and sampling of veneers, on their way to the warehouse piles.

Sawn Mahogany Veneers. Some users of thin mahogany prefer a veneer manufactured on a segment veneer saw, regardless of the fact that the "kerf waste" is more than the equivalent of a veneer. (See Illustration 102.) In veneer sawing, the flitches are not steamed nor heated, but are taken directly to the veneer saws from the bandmill. The standard thickness of sawn veneer is 1/20 inch but veneers are also sawn 1/16, 1/12, 1/10, 1/8, 3/16, and 1/4 inch. The

drying, numbering and sampling of sawn veneers is similar to that of the sliced.

### Half Round Black Walnut

American black walnut lends itself advantageously to several methods of veneer cutting, depending on the size of the log, the probable character of figure available, and the purpose for which the veneer is to be used. Walnut logs are ordinarily crooked and irregular in growth, and the two most desirable parts for veneer production are a crotch, where large branches or twin trunks join, or a stump where the trunk spreads out bell shape and the larger roots begin. In most other woods the cross-grained wood in stump and crotch is regarded as usable for firewood only. Crotches commercially come in the form of "chunks," shaped somewhat like a very shallow throated "Y." Their length is seldom more than twice their diameter at the butt end.

Stumps. These are ordinarily about half under and half above ground. It is much easier to secure stumps by digging down around the root some two or three feet, cutting off the large roots and allowing the tree, as it falls, to pull out and free as much of the stump as possible. This gives longer and more desirable stump wood than when the tree is felled, in the usual way, by cutting a foot or so above the ground. Digging out such a cut-off stump is a most laborious and difficult job.

In the third mill to be visited, these great stumps can be seen with the bark still on and shaped somewhat like an irregular bell, as may be noted in Illustration 103. The first step in the process is when the giant cranes drop the stumps into the cooking vats already described. Here they stay for several days, until they are thoroughly softened, when they are lifted out, barked, trimmed and halved vertically through the heart, up and down, as shown in Illustration 104. But here again is

Illustration 103. Showing bell-shaped black walnut stump, as it is delivered to the veneer mill. Stump ready to be flitched.

Courtesy, Wood-Mosaic Co.

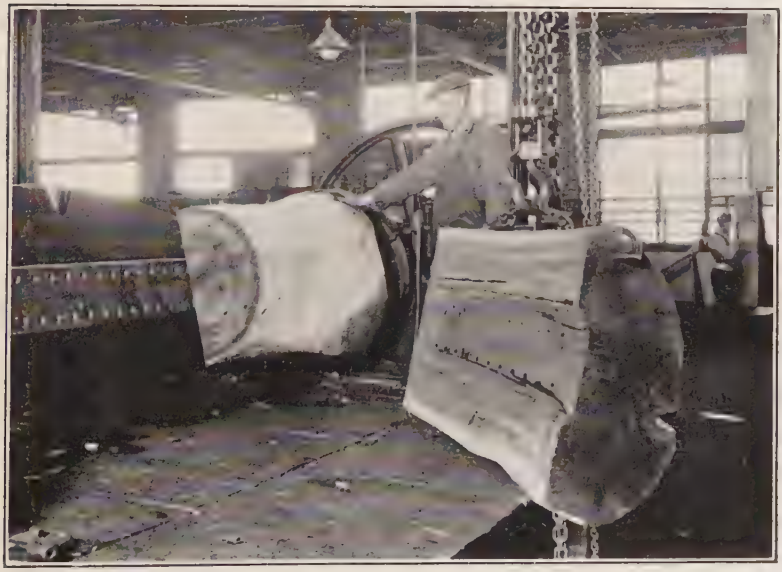

Illustration 104. Showing the same walnut stump, peeled, halved, trimmed, bored, and recessed ready to be bolted on stay log. Half in background is bolted to stay log.

Courtesy, Wood-Mosaic Co.

Illustration 105. Showing half round black walnut stump veneer as it is taken from the lathe which latter is equipped with stay log.

Courtesy, Wood-Mosaic Co.

an opportunity for keen discrimination, in deciding the particular cut that will develop all the finest figure nature has grown into that particular stump.

"Reading the figure" is the expression for this exercise of skill, a species of mill woodcraft which approaches the discriminating judgment that governs the cutters and loggers in the forest.

The relative importance of this insight can be glimpsed from those incidents which sometimes tell the story in almost unbelievable figures. One veneer mill still tells the tale of a rare old walnut tree and stump handled some years ago which, when skilfully marked and cut, yielded nearly thirty thousand dollars' worth of first choice art veneers, the find of a lifetime of course, but a record achievement for all that.

The particular skill lies in discerning the point and angle of cut to yield the finest grain figure and character markings in the final veneer sheet. When the stump thus marked is sawed through the center into its resultant flitches, the back of the flitch, originally the outside of the tree, must be sawed parallel to the face of the flitch to give a flat surface that can be attached to the stay log. Into this back, bolts are sunk to hold the flitch firmly to the stay log. Consequently, when the half-rotary cut begins, each slice of veneer has the bell-like contour of the stump without the sacrifice of the flaring ends, which often prove to be of considerable value. Illustration 105 shows the sheets of stump walnut veneer as they drop off from the stay log.

The sheets of veneer in a flitch are kept in sequence, sometimes being numbered, as was described in quartered oak, and are reassembled in flitch form after drying. Flitches are usually sampled, from top, center, and bottom of flitch and the footage area measured approximately for computing sales value.

The process of halving, mounting and cutting crotch veneer is quite similar to that of the stump just described.

Less highly figured walnut veneer, such as stripe wood,

etc., may either be cut on the stay log or on the slicer, without material difference in character of stripe.

Sliced Stripe Walnut. The choice, clean bodied, large logs of walnut 20 inches and over in diameter, sometimes 18 inches, are adaptable for sliced veneer. The log should go through the sawmill and be cut into an octagon shape, cleaning off the bark and excess sap wood. Then the log can be halved at the sawmill or it can be sent on in the full octagon shape for

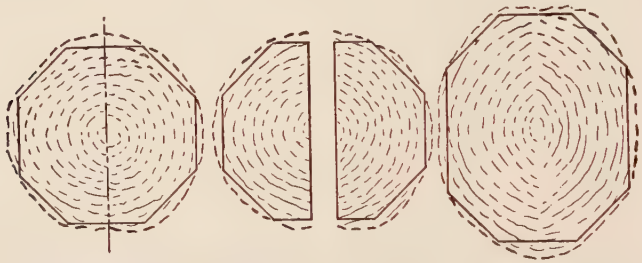

Illustration 106. Showing octagonal sawing to prepare walnut logs for flitching, some logs are halved and some are quartered.

slicing on stay log as indicated in Illustration 106. Quartered walnut flitches are produced as the oak previously described.

The flitch is then taken to vats where it is either cooked in hot water or steam until it is softened and ready for the stay log, or slicer. The sheets are cut and kept in sequence as they drop off the machine, sometimes being numbered. Care must be taken to have the knife and pressure bar of the machine in perfect adjustment, as well as the log softened, so that veneer is not ruptured while cutting.

The veneer, after it is cut, will begin immediately to change color, as it goes through a sweating stage. Care and study should be given by the manufacturer to the timing of this sweating period to obtain the most uniform color desired. Light colored stocks are produced in a short time. Darker stocks require a longer sweating period. A greenish cast appears in the veneer when first cut. This must be allowed time

to disappear. The veneer after sweating is then dried, either in finger racks or mechanical dryers. When dried, it is reassembled in sequence, measured and two, three, four or five samples are drawn from the flitch showing top, middle and back of the flitch. These samples are to indicate character of figure and size to prospective customers, or to enable the manufacturer to plan his own cuttings later, when the flitch is put into use.

An incident in a cutting mill is worth repeating and it is quoted by permission:

> As we stood watching the slicing machine shearing off wonderful sheets of beautiful walnut veneer, there was a hand raised suddenly and a call from out front where the handlers took the sheets as they came from the machine. The little bell rang, the great machine sank to stillness. The operator in charge threw back the flitch table from the knife, stepped into the passage between, and in less than no time was chiseling out a discolored patch in the flitch about as big as a silver dollar. "Old nail, grown over, I reckon," was the only comment. A moment later, out it came, a broken piece of old wrought iron nail, embedded there in the young tree by some thoughtless youngster perhaps, seventy-five years ago! The practised eye of the receiver-operative had detected the false color, everything stopped, the cause removed, a slicer knife worth many hard earned dollars was saved; the little bell rang, and the procession resumed as if nothing had happened. Things like that reveal the humanness in factory operation, the control of brain at every step, watching everlastingly for the negative factor that would ruin mechanical perfection, intellect governing, always.

Walnut veneer logs from 12 to 15 inches in diameter are too small to go on the slicer, and are usually valuable enough (if straight and sound) to be flitched and put away on the stay log, where the veneer produced is somewhat wider than when cut on a slicer; i.e., a smaller log on the stay log will produce veneer of nearly the same width as a larger log on the slicer.

If the heart side of the flitch is attached to the stay log, as

shown on the right in Illustration 107, it is known as true half round, since the concaveness of cutting is the same as of the growth rings of the tree. If the narrower face, or bark side of the tree, is bolted to the stay log (see left side of Illustration 107), the resulting operation is known as "back cutting," i.e., the curvature of the resulting sheets of veneer is opposite to the growth rings in the tree, and the stripe figure effect is considerably enhanced. In the back cutting the first slices come

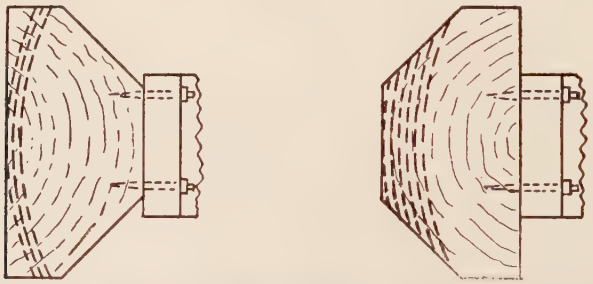

Illustration 107. Showing at left a flitch of walnut, bolted to a stay log for "back cutting," i.e., first sheets are cut from heart side. At right is shown true "half round," when veneer is cut in same position as in rotary, but with much larger diameter of cut.

from the heart of the tree, or heart wood, and in the true half round the first slices are from the outside of the tree or sap wood. The sap wood of walnut is much lighter brown in color than the dark brown or "black" wood of the heart, as it is called. The sap wood veneer is much less desirable since the furniture demand is for the rich dark finishes that are difficult to obtain from the light colored woods. Hence any procedure in veneer cutting that increases the yield of "black" wood is highly desirable and, therefore, the stay log method is particularly adaptable to black walnut logs.

## Rotary Veneer Production

Sawing, slicing and half round cutting are usually regarded as the means of producing figured wood veneers, suitable for

face work. Sometimes these methods are used to preserve strength and wood fibre, as in sawn piano wrest plank. In the aggregate, however, only a small quantity of veneer comes through these channels of production.

Rotary cutting, on lathes, gives far greater production and more economical costs, wherever veneer figure can be disregarded and production based on quantity rather than quality. Some figured woods, like bird's-eye maple, curly birch and the like, are best cut on the rotary, since the growth producing figure is radial, and its best display is a cut directly across such figure. However, rotary cut figured woods are the exception.

Rotary cut veneers, aside from the few figured varieties mentioned above, are seldom stored or sold on other than a gross area basis, in contrast to the flitch method. Considerable quantities are carried by wholesalers who stock such regular lengths and widths (including fractional multiples of widths) as are required by the stock panel, interior trim and furniture trade.

Nearly all woods are cut into rotary veneers, but space allows the description of only five typical species, northern birch, southern gum, white and red oak, poplar cross-banding and western Douglas fir.

Rotary Cut Birch. From the Atlantic seaboard to the Great Lakes states is quite a jaunt, but necessary if we are to see virgin growth birch timber. Northern Wisconsin and Michigan are the chief centers of the birch veneer industry, although considerable quantities are still cut in the northeastern states.

But let us follow the stages of veneer manufacture from the woods to the dryer. The birch trees in the woods are straight, sound and clear, often 60 feet to the lowest limbs, and sometimes logs are 3 feet across the butt. Most of the logging is done in the winter, under the ministrations of the picturesque lumberjack who piles the logs on sleighs, then on to railroad

flat cars, from which they are "decked up" into great piles at the veneer mill, as shown in Illustration 89, page 187.

Birch logs keep well in cold weather and veneer cutting is at its greatest volume from November to June, slowing down for the summer and early fall. During unloading from the railroad car in the yard, logs are sorted for species, size and grade, so that each lathe may be supplied with suitable raw material without too much handling of heavy logs.

The logs go from the yard to the grotesque drag-saw where lengths are cut with adequate allowance for trimming. The resulting birch bolts or blocks are rolled into hot water vats and soaked for varying periods at temperatures not exceeding 180° F.

The series of illustrations (108 to 111) show respectively the cutting of logs to length on the drag-saw, conveying the short length logs to cooking vats, removing logs from vats, and peeling bark from logs.

This cooking or "simmering" process softens the log for cutting and flattening out, and also cleans off the dirt and loosens the bark. The block (with bark removed) is lifted into the lathe by a miniature derrick, and the irregularities skinned off until the log is well rounded and ready to convert into veneer.

Experience and skill are needed to determine whether the log reveals a quality and texture that will make "faces," "selected red," "curly," crossing or cores. When a decision is reached, the feed mechanism is adjusted for thickness, and the spurs set for lengths. The sheet of steaming wet, soft veneer flows out in strips 40 or 50 feet wide (see illustration 112) piled one above the other on clipper table or chain, until the log has yielded its full measure down to the core. This center is then sawed into lumber for crating or other purposes. (See Illustration 113.) The pile of sheets is moved by a chain or belt to the clipper knives and sheared to the desired width in books from 1 to 3 inches thick. From the clipper these di-

Illustration 108. Drag-sawing logs into lengths or bolts, previous to cooking or steaming.

Courtesy, Underwood Veneer Co.

Illustration 109. Short logs, prepared for cooking vats (note counter weighted trap doors at left). Drag-saw may be seen in background.

Courtesy, Bird's Eye Veneer Co.

Illustration 110. Log just removed from cooking vat, ready to be barked, or peeled.

Courtesy, Underwood Veneer Co.

Illustration 111. Peeling bark from logs which have just been removed from cooking vats.

Courtesy, Bird's Eye Veneer Co.

mensioned veneers go to the dryer where the moisture is reduced to the desired point, five to ten per cent, according to subsequent requirements.

In this way is produced a large proportion of the birch veneers used in making curved opera, moving-picture theatre and auditorium seating, usually 5-ply construction and about 2 feet square. The best veneers are chosen for faces, the next for backs, then crossings (sometimes more than one piece widths) and finally cores. The faces and crossings may be 1/20 or 1/16 inch thick and the cores from 1/16 to 1/8 inch thick, according to requirements.

The woods operations yield not only birch of various species, but maple, basswood, elm, ash and oak. All are cut similarly, the bass used more for crossings and cores, the elm, ash and oak for faces on large panels, interior trim, and doors, and the maple where strength and hardness rather than appearance is required.

Curly birch logs may be cut on the lathe, as above, or on the stay log, or on the slicer, according to value and ultimate use.

While the waste in the form of ends, edges and irregular sheets seems to be excessive to the uninitiated, yet there is a studied balance between the value of material and the use of labor to salvage it. The better grade logs will sometimes yield as high as seventy-five per cent of their scale in usable veneer.

After drying, the veneers are sorted carefully for perfection, color and utility. They then go to the shipping room for crating and sale as veneer, to the storeroom to temper until required for orders, or direct to the jointer and tapers to prepare for laying up. Stocks that are crated for sale are made up and marked in standard packages for convenient handling and storage.

Rotary Cut Gum. Gum is the staple wood of the southern veneer mill, and it is used for everything from the high-

est grade figured wood, laid in balanced and matched patterns for face veneering, to the wholly utilitarian purposes of cross-banding, cores and backs, as described under "poplar." The family of gum trees is numerous, the wood is solid and close grained, and the logs large in size and relatively free from timber defects. Approximately one-third of all veneer cut is from the gum tree family.

Figured gum, a peculiar and unique arrangement of dark and light pigment, is sometimes described as "streaky." Prime figured logs are usually sliced on the quarter to give better display to the color and figure.

Red gum, or heart wood, is highly regarded by the furniture and cabinet trade, since it not only takes an excellent finish in its own natural and shaded colors, but serves as an excellent imitation for both walnut and mahogany.

Gum logs grow largely on ridges surrounded by swampy land and must be cut and hauled in the dry season, or southern summer, and decked up or stored in ponds for the balance of the year. In the months of July, August and September and sometimes as late as October, gum logs not stored under water are made absolutely valueless for production into lumber or veneers by an insect which bores into the sap of the wood all the way to the heart. Sometimes the insects will entirely destroy the sap portion of a log in the space of a few days' time. During the rainy season much of the timber land is impassable for man, beast or tractor.

The lathes for cutting southern gum are large, and the logs can be ordinarily cut clear down to the smallest size permitted by the lathe centers. The conversion of a gum log into veneer is shown in Illustration 114. Note the large size of log from which considerable veneer has already been cut. The outer veneer, being sap wood, is the best from the standpoint of texture and strength and the inner veneer, being heart wood, is the red gum so highly prized by the furniture trade for its color and tightness of grain.

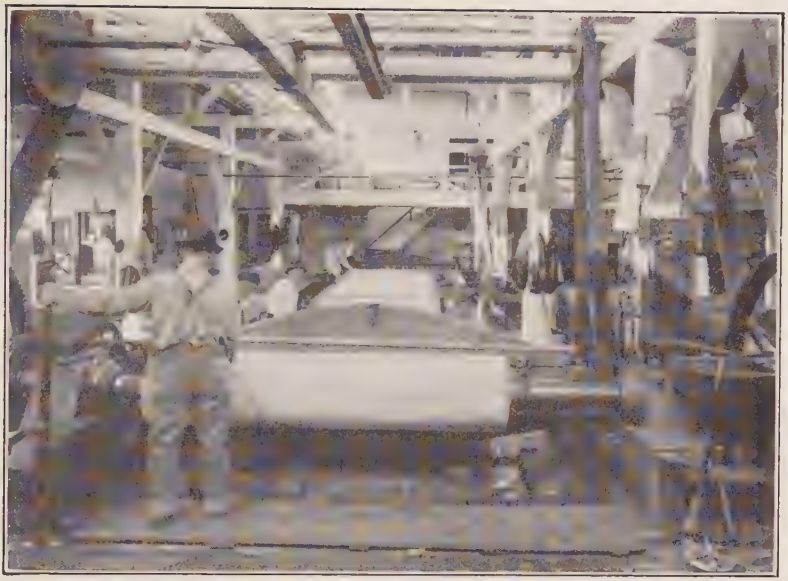

Illustration 112. Rear view of lathe, with wide sheet of veneer extending over to clippers in the background.

Courtesy, Bird's Eye Veneer Co.

Illustration 113. Circular saw, for reducing veneer cores into lumber and crating stock.

Courtesy, Bird's Eye Veneer Co.

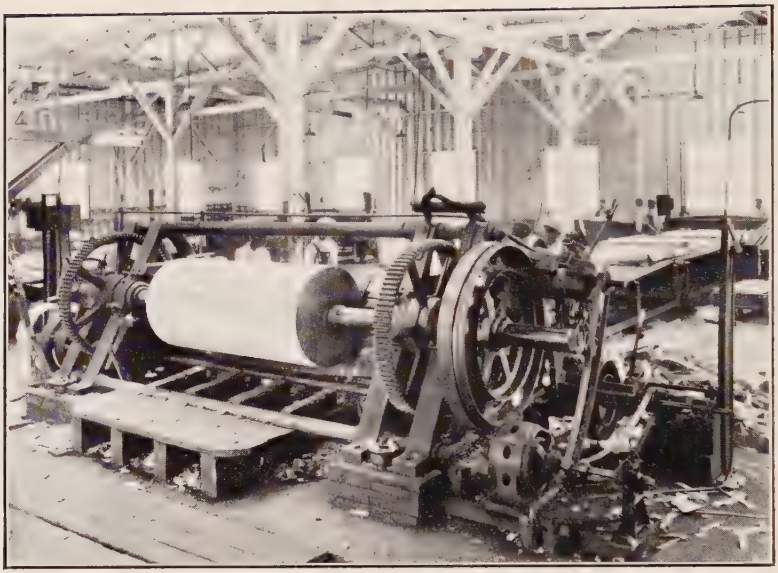

Illustration 114. Showing a gum log in an electrically driven lathe, with clipper at extreme right. The cut veneer is laid out on table between lathe and clipper, and is sized singly or in piles of several layers.

Courtesy, Louisville Veneer Mills.

Illustration 115. Showing three strips of rotary cut veneer from an oak log in lathe.

Courtesy, Underwood Veneer Co.

Gum at one time bore the reputation of being an unusually "warpy" wood, a reputation that seems to have developed when its character and treatment were not well understood. Under proper conditions of manufacture and use, however, it is the equal of any except the highest priced veneers, and by many is regarded as a most desirable veneer for plywood use.

Rotary Cut Oak. This is one of the standard veneer woods, used extensively in interior trim, office and library furniture. Oak veneer has a hard durable surface when cut into 1/12 and 1/16 inch veneer. Thicknesses of less than 1/20 inch are likely to be too fragile and to break easily. The unique growth with medullary ray, that makes the splash figure in quartered oak is also responsible for the fragility of the thin rotary veneers. This medullary ray is radial and, therefore, makes it easier to break rotary oak veneer across the grain.

The cutting of rotary oak veneer is shown in Illustration 115, in which the lathe spurs are set to cut three strips of veneer, which strips will be piled each on the other for clipping.

The rotary cutting process is so similar to gum and birch that it will not be described in further detail.

Rotary Cut Poplar. This wood is used extensively for rotary cut cross-banding, backs and cores. The texture is admirable for these purposes as the logs are sound, the veneer does not tear easily, the sheets of veneer keep flat without much crinkling or splitting and poplar makes an excellent glue joint.

Choice straight bodied trees, 20 inches and up in diameter are selected for producing the best grades of cross-banding. These logs are sawed to length in blocks of single or multiple dimensions and marked for rotary cut cross-banding. A few inches of extra length are allowed so that ragged ends can be "spurred" off during cutting and thus produce clean and parallel edges.

These blocks, by some manufacturers, are cooked in water or in steam vats, by others are conditioned and cut cold. The

blocks have the bark removed and are then set in a rotary lathe and veneers cut to desired thicknesses. Some prime logs will produce clean wide lengths frequently 12 feet and sometimes 16 feet long. The sheets of veneer are then passed over a conveying table to a clipper, where, in book form (many sheets at a time) they are chopped to required width. This veneer is then ready for drying and can either be air dried in finger racks or by mechanical dryers, as described in Chapter XX. Stock is then inspected, crated and ready for shipment.

Ordinarily, there is no desirable figure in poplar, hence no need to keep sheets of veneer in sequence.

Sometimes sheets of veneer are separated to such widths as to represent one circumference of the log. More often, stock is cut without regard to its position in log, and is reduced to "whole," "halves," "thirds," and sometimes "quarters" of the final size, with allowances for jointing. Such a variety of widths insures the use of all veneer, after defects are clipped out.

The best cabinet and panel work is produced by one piece cross-banding, although much use is made by consumers of part pieces, jointed and taped. The standard cross-banding thickness is 1/16 or 1/20 inch. Other thicknesses both thinner and thicker are produced.

Poplar Core Stock. This is thicker veneer produced in similar fashion to the cross-banding above. This core stock is used for centers in 3-ply or 5-ply panels. The standard commercial thicknesses are 1/8, 3/16, 1/4, and occasionally 5/16 inch.

Rotary Cut Douglas Fir. The woods of the Pacific Coast timber belt are nearly all coniferous, usually termed softwoods (as contrasted with the flat leaved trees producing the hardwood). Douglas fir is the principal species, and is used extensively for timbers, construction and interior trim. Most of the trees from which Douglas fir veneer is manufac-

Illustration 116. Showing the immense size of the Douglas fir logs, with one in lathe, and another suspended from chain hoist to go into lathe. These veneers are extensively used for doors and interior panelling.

Courtesy, Wheeler Osgood Co.

tured were standing when Columbus discovered America. All of them were proud monarchs of the forest when the United States of America elected George Washington as President.

It is from such trees that Douglas fir plywood is manufactured—from the selected logs of these magnificent timber tracts. Log rafts are carefully inspected, and the large clear logs go to the veneer plants.

These huge logs are cut into 6, 8, or 10 foot lengths with the aid of chain-saws, and these shorter log sections, or blocks, are lifted from the water of the mill-pond by large cranes or hoists and carried to correspondingly large steam rooms or boiling vats, where they are steamed or boiled in water for twenty-four hours or more. This steaming or boiling has a tendency to reduce the hygroscopicity of the wood (the tendency of the wood to absorb moisture) and hence the wood that has been treated in this manner will not "work" as much under changing atmospheric conditions as ordinary lumber. This steaming also temporarily softens the wood, so that it can be readily peeled into sheet-stock for the manufacture of veneers that go into plywood.

After steaming or boiling, the thick, heavy bark is pried off, and the blocks are placed in giant lathes of the so-called "Pacific Coast" pattern. (See Illustration 116.) After carefully centering the log so that the most desirable figure will be produced, the wood is peeled into sheets of veneer ranging in thickness from 1/10 to 1/4 of an inch. This veneer is then cut into proper widths on an automatic clipper before being passed through a continuous dryer, where in an atmosphere of high relative humidity and temperature, the moisture is rapidly evaporated and the pitch or resin in the wood is "killed" or solidified without impairing the strength of the wood. This treatment further reduces the hygroscopicity of the sheet-stock.

The dry veneer is then carefully graded and carried to the glue room, where it is built up into 3-ply or 5-ply panels. It

is customary to use three or five equal thicknesses in making fir door and interior panels, selecting the best figured and most perfect veneers for face stock, and using the other veneers for crossings and cores. The veneers are customarily cut to 1/7 inch, in which three thicknesses, when glued up, sand down to full 3/8 or 1/9 inch to make a scant 5/16 inch. The veneer and plywood processing is practically one continuous operation, since the sheets are large enough so that faces rarely require jointing and taping. Cores and crossings are thick enough so that they can be laid together snugly without taping as is required in thinner veneers. Considerable veneer is shipped to the eastern market in the form of sheet stock to be assembled with other veneers in many kinds of plywood.

Rotary cut fir has a large conspicuous grain, made by the growth rings or denser wood of the summer (or dry season). This grain character is frequently so regular that it can be centered in a door panel with pleasing effect. See Illustration 83, facing page 176.

# CHAPTER XX

## PREPARING VENEER FOR PLYWOOD

Veneers of different cuts and grades are utilized not only for plywood faces, variously figured or plain, but also for crossbanding to reinforce both faces and backs; for backs, concealed or exposed; and for cores in panels, chiefly due to economic reasons.

The manufacture of veneer has been followed to the point where either a flitch of figured veneer or a given footage area of plain and unfigured veneers, or both, are available for assembling into sheets to be eventually glued into plywood. Before the veneers are ready for gluing together, the different sheets must be prepared as to selection, size, arrangement and dryness. This is technically called making them "ready to lay."

This branch of veneer fabrication is inserted at this point, since it bears such an intimate relation to the methods of veneer cutting, handling, drying, and the resulting varieties of veneer.

Some veneer mills make a practice of cutting, jointing, taping and trimming veneers for their trade, particularly in the plainer and less ornate lines of furniture and panels.

This veneer preparation is a separate department in plywood factories, quite distinct and isolated from the subsequent gluing operations into flat and curved work. Therefore, those readers who prefer to consider this chapter as a part of plywood making, may read it into Chapter XXIII, *et seq.*

### Drying of Veneer

Immediately after cutting from the log or flitch, the veneers must be given a preliminary drying to prevent mildew or

discoloration (except in walnut where darker shades are desirable) and to reduce weights for shipment.

Air Drying. This may be done by air drying out-of-doors, under favorable climatic conditions, but preferably is done in lofts or dry rooms, where temperature and humidity can be controlled within desirable limits. Artificial dryers, under forced draft, are frequently used to expedite this preliminary drying. This preliminary drying, by whatever process selected, should reduce moisture content to approximately twelve per cent. This is about the equilibrium point at which moisture will be absorbed or given off slowly in ordinary storage and warehouses. Some authorities prefer more than twelve per cent, so that highly figured cross-grained veneer will be less liable to break in handling. This moisture content is determined by weighing small samples on a scale, drying to a minimum weight (bone dry) in an electric oven, immediately reweighing the identical samples, subtracting result from initial weight, and computing as follows:

$$\text{Per cent of moisture content} = \frac{\text{Weight lost in oven}}{\text{Minimum bone dry weight}} \times 100$$

Air drying out-of-doors is seldom practised because of the uncertainty of the weather and the handling labor involved. It is used some in southern states for drying thick veneer.

Loft Drying. This is quite commonly used and by some preferred as producing the best quality of veneers. Sheets of rotary veneer are generally hung from overhead wires by means of friction clips or spring hook devices. Strips of sliced or sawed veneer are usually placed on edge in finger racks, to separate the sheets and still hold them relatively straight and flat, as shown in Illustration 117. Such lofts or drying rooms should have ample ventilation and be maintained at temperatures around 90° to 100° F. and humidity of 60 to 70 per cent. This is as hot as can be endured by workers, and

lower humidities often cause crinkly stock, due to rapid and uneven drying. See also Illustration 100, page 192.

Progressive Dryers. Thicker veneers are often piled flat on wheeled or castered trucks or kiln cars (see Illustration 118) the sheets being separated by frequent use of stacking rack sticks, and the cars are forwarded progressively through a drying chamber, in which graduated temperature and humidity

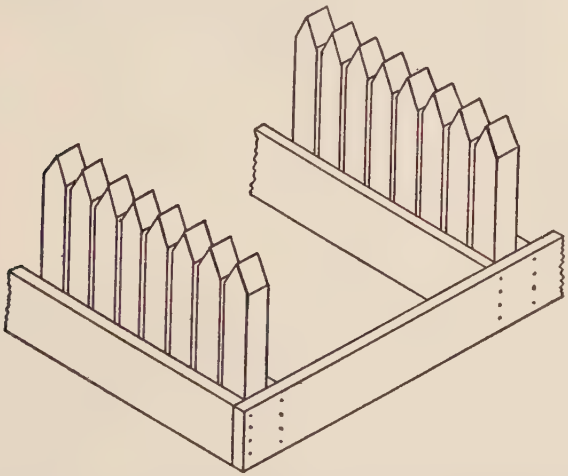

Illustration 117. Showing drying racks, for keeping strips of veneer separated, holding them straight during drying, and maintaining sequence of pieces in each flitch log.

conditions are maintained throughout. Such a kiln is shown in Illustration 119.

Another type of artificial dryer has a series of open mesh chains or network wire conveyors, between which green veneers are laid, as shown in Illustration 120. The veneers, held flat by the conveyors above and below, are passed once, twice, or more times through the heated chamber until delivered at one end or the other, with the moisture content sufficiently reduced. The main central heated chamber, through which the conveyors pass, is kept at desired temperature and humidity by means of fans and properly distributed steam-heating coils.

The speed of the conveyors may be regulated so that the drying cycle through the machine, will consume the time necessary to evaporate the moisture to the desired degree.

Roller Dryers. The roller dryer consists of a series of steam-heated revolving cylinders, the machine being usually 100 or more feet long, and several tiers or layers high, as shown in Illustration 121. All rollers are driven by means of gears or chains, and the sheets of veneer are passed between the hot rollers as many times as is necessary to remove the moisture content. Steam coils are sometimes used on this type of machine so that veneer will be heated between rollers at a time when moisture can escape from surface, in which event the rollers function as veneer flatteners. The speed variations are similar to the endless chain dryer previously described.

Platen Dryers. The platen dryer, shown in Illustration 122, consists of a vertical series of smooth, flat, steam-heated leaves, or platens, between which sheets of veneer are laid. The platens are alternately squeezed together to flatten the veneer, and opened up to allow the moisture to escape from the wood surfaces. This type of dryer is most frequently used to "iron out" and dry veneers about to be prepared for laying into plywood. There is danger, in flattening cross-grained figured veneers, that they will either split under pressure, or become so dry as to break in handling. Some authorities advise working such fragile veneers, at a moisture content of ten to fifteen per cent. Except for such instances, veneers should be platen dried down to about six or seven per cent, which degree of dryness will remain approximately stationary in ordinary workrooms. Veneers 1/8 inch thick and up are frequently put through platen dryers.

The development of the last few years has produced a progressive platen dryer, shown in Illustration 123, which combines the flattening effect of the platen dryer, and the longitudinal movement of the progressive or roller dryer. The

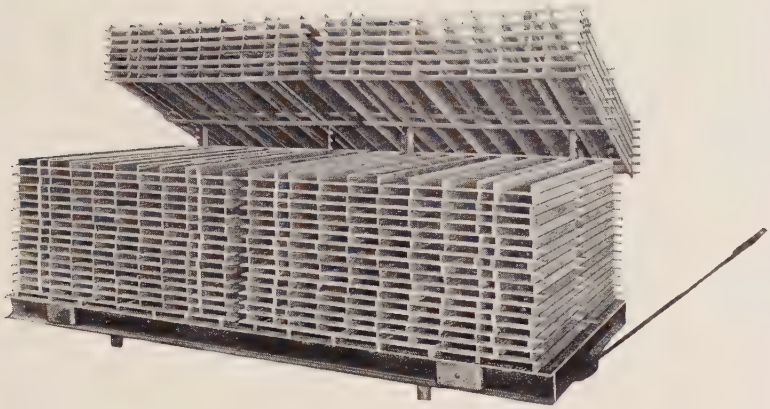

Illustration 118. Stacking racks on a truck used for handling green veneer through a progressive dryer.

Courtesy, Hope Fan & Blower Co.

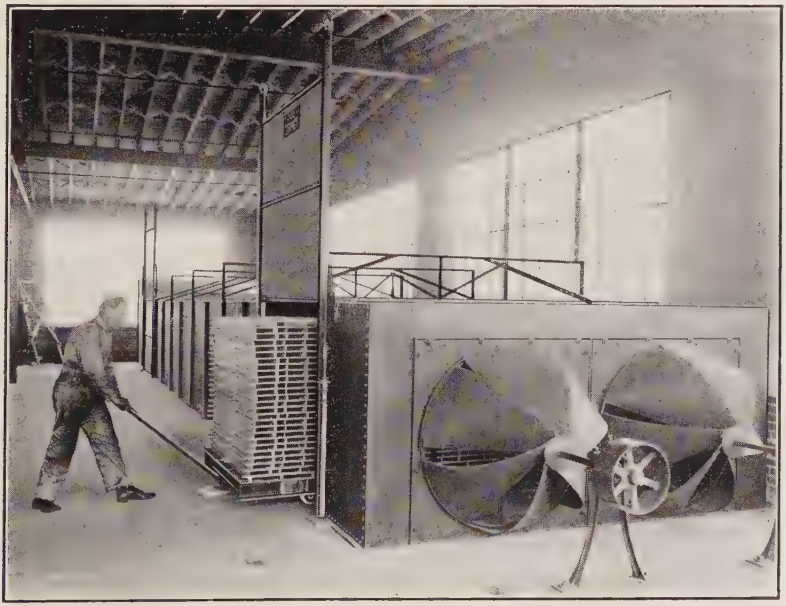

Illustration 119. Showing previously illustrated racks being placed in a progressive dryer from the side.

Courtesy, Hope Fan & Blower Co.

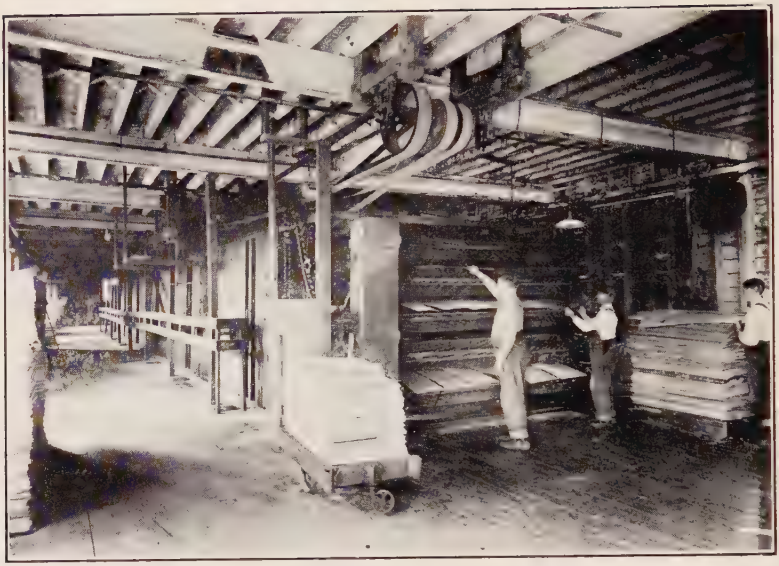

Illustration 120. Progressive chain belt dryer, in which veneers are held between endless belts of open mesh construction.

Courtesy, Proctor & Schwartz, Inc., and Underwood Veneer Co.

Illustration 121. Veneer dryer consisting of a series of heated steam rollers, between which the veneer is pressed and dried.

Courtesy, Coe Manufacturing Co. and Harbor Plywood Co.

alternate batteries of platens in the machine have an oscillating motion, clamping and advancing the sheets of veneer several inches at each cycle. On arrival at forward point of cycle, the moving platens release the veneer (now grasped by the non-traveling platens) and return to their first position for another "bite" and forward motion of veneer.

The practice varies widely in different plants, as to which type of dryer is most suitable for the preliminary drying of green veneer, and the final drying of veneer preparatory to laying, but in most instances some type of platen dryer is utilized to flatten out veneers before jointing and matching.

During drying by any process, figured veneers should be maintained in order of their sequence.

## Trimming to Size

The veneers are now dry and ready to be cut to dimension.

This work may be done, using a band or a circular saw (a common and economic practice for sizing to dimension thick veneer cores and cross-banding) where an aggregate of an inch thickness may be sawed at once, the rough sides and edges being unobjectionable as they are trimmed off after gluing. Often long, unwieldy flitches of face veneer are rough dimensioned to length by means of saws, although care must be exercised not to interfere with subsequent matching and balancing of figure.

Clippers for Cutting Face Veneers to Dimension. The medium figured, relatively straight grained face veneer is usually cut to dimension by use of veneer clippers, shown in Illustration 124, and on which several sheets at a time may be clipped (shear motion) to approximately one inch longer and wider than the finished dimension. This over-length and width is for final trimming after gluing.

Description of Faces and Backs. The width and choice of face veneers must be carefully considered by the

clipper operator, since faces and backs may be specified in any of the following ways:

*Faces:* One-piece
Two-piece, center-matched
Balanced joints
Random joints
Selected for color
Sap no defect

*Backs:* Sound
Reject

*One-piece face* is a self-explanatory term, and can only be secured in narrow sizes from sliced, sawed or half round veneer, which in turn is limited by width of flitch less trim allowances. Rotary cut veneer will permit wide one-piece faces, which may be selected for centering of figure or design.

*Two-piece center-matched face* applies to larger sizes than can be made from single strips of veneer. In order to prevent angling effects and unbalanced figure or color, the best practice requires that two-piece faces have a center joint, the two pieces being of equal width laid together in the same manner as the leaves of a book opened from the binding. To obtain this balance or matching of design or figure, it is necessary that one-half of the veneer shall be "loose side up" and one-half "tight side up." "Loose side up" means that the cutting check in one-half of the face veneer will be more apparent than in the "tight side up," and under the staining, filling and varnishing process there is sometimes apparent between the two, a variation as to color shading. This is often criticized by the uninformed as a defect in workmanship, but it is an actual difference in the character of the wood and is on the contrary an indication of skilful craftsmanship.

It must be apparent that veneers for two-piece faces, or for other construction, for that matter, should be carefully selected. Discriminating purchasers sometimes specify that faces of rot-

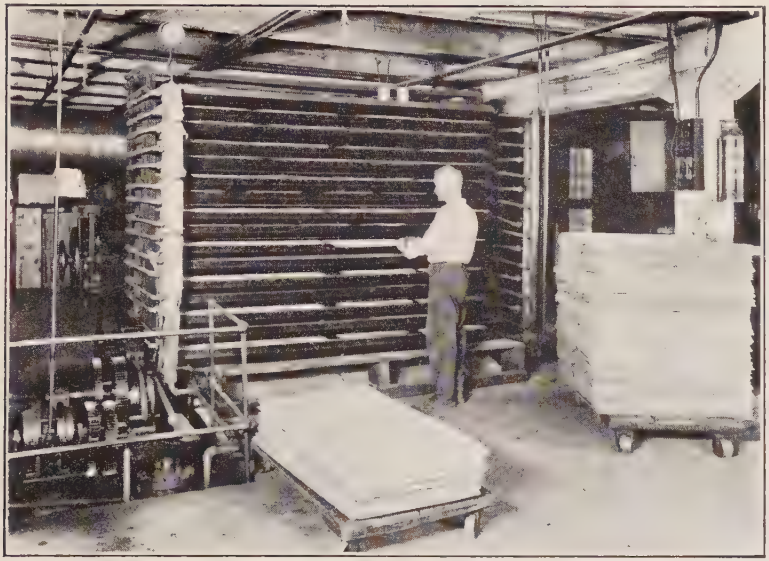

Illustration 122. Showing dryer, with steam-heated platens, flattening and drying veneers. Pile at left is flat and dry, while pile at right is waiting to be dried.

Courtesy, Merritt Engineering & Sales Co., and New Albany Veneering Co.

Illustration 123. Showing a recent type of dryer that is a combination of platens and the longitudinal movement of a progressive dryer.

Courtesy, Merritt Engineering & Sales Co. and Illinois Veneer Co.

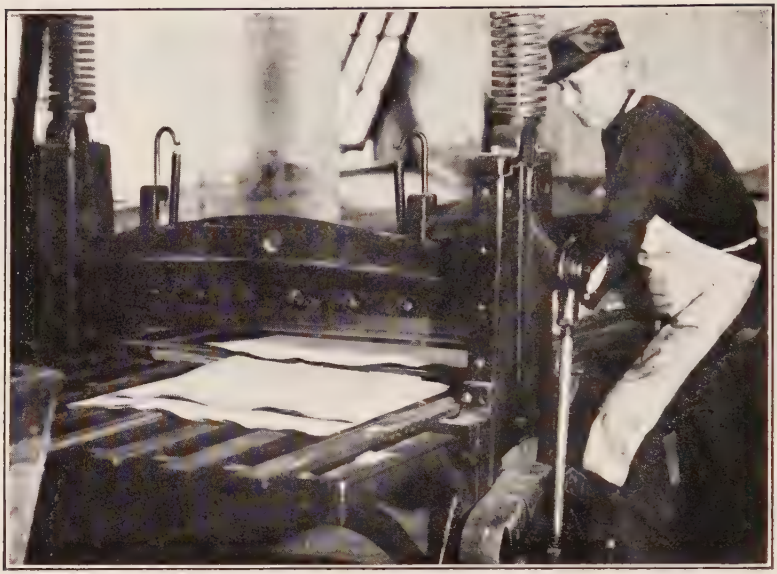

Illustration 124. Showing clippers for trimming veneers, preparatory to taping. Clipper knives have a "scissors" cut.

Courtesy, Berkey & Gay Furniture Co.

Illustration 125. Showing packages of veneer, passing through edge jointer. This operation follows the clipping and precedes the taping process.

Courtesy, Underwood Veneer Co.

ary veneer be center matches. However, general symmetry rather than exact balanced figure will be the usual result of such matching.

*Balanced* and *random joints* are the terms used to indicate whether two or more face joints must be symmetrically located or whether they may be allowed to appear at random, according to the run of average veneer widths.

*Faces* may be *selected for color,* as in maple or birch, where clear white or red veneer is desired, and other colors must be clipped to waste or saved for back veneer.

*Sap no defect* means that the sap wood, or lighter colored veneer, at edges of flitches, or in the outer layers of rotary cutting (from log) is not objectionable and may be used for faces.

*Backs,* preferably, should be of the same thickness and wood as the faces, so as to give true equalized stresses in the final glued form. However, this is not necessary and quite the larger percentage of commercial plywood production is manufactured using a face veneer of one wood and the back veneer of an entirely different species. Sometimes plywood is manufactured with face veneer two sides, as a door to be frequently left open, or for any purpose where both sides are exposed to view.

*Sound back* refers to back veneer, clipped free from imperfections, but which may be random jointed and unselected for figure or color.

*Reject back* implies backs which are to be concealed from ordinary view, like the under sides of table tops, and which may have imperfections and open joints to the extent permitted by the specifications governing them.

## Jointing, Matching and Taping

Joints between sheets of face veneer must be practically imperceptible in the finished plywood product, except as their

presence is evidenced by change in the direction of the grain or figure of the wood.

Jointers. Sawed or clipped edges are planed down smooth and true on a veneer edge jointer, as shown in Illustration 125. A package of veneer, approximately an inch in thickness, is "jogged even," and clamped on a reciprocating table which carries the edge of the package over a rapidly revolving special planer or sticker type of cutter head. These cutter heads sometimes contain as many as sixteen knives to each head. (See Illustration 126.) Light cuts must be taken, as a heavy cut might produce uneven or torn edges. More than one cut may be made if necessary to smooth or straighten the edges. The table feed must be slow and the cutter knives sharp and in proper adjustment and balance to produce true edges.

For jointing veneers for diamond-matched, V-matched, four-piece, and butt-match face veneers, many manufacturers find the guillotine clipper and jointer a superior tool, by the use of which more accurate and more perfect matching and jointing may be accomplished. (See Illustration 131, facing page 217.)

Matching Veneers for Faces. After face veneers are properly jointed, they are taken to the matching table and clippers. This is one of the most important operations found in the modern plywood plant, as at this point the operator must carefully select and assemble each separate sheet of fancy (as well as plain) face veneers so that when the various assembled sheets are taped together they are ready to lay up as a "complete face." The character, the figure, as well as the color, must be exactly or accurately matched at each taped joint. Faces are usually matched and clipped to a dimension one inch larger each way than the ultimate finished size of the completed plywood unit.

Taping Machines. The veneer is now ready to be taped together preparatory to gluing into plywood. The most con-

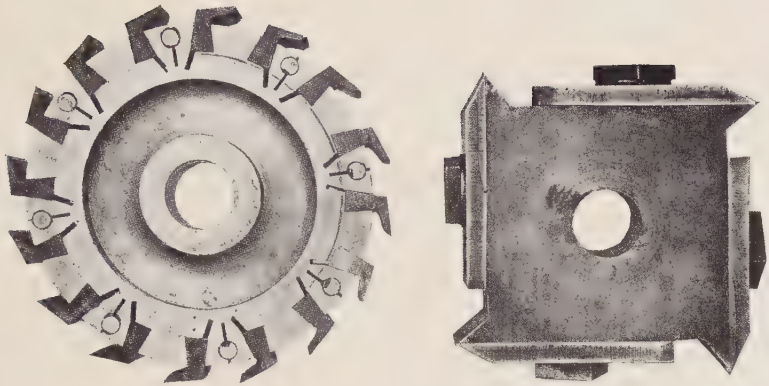

Illustration 126. Showing at left a sixteen-bit cutter head for veneer jointer, to insure perfectly straight and true edges of a veneer joint. At right is the standard four-bit cutter head.

Courtesy, New Albany Veneering Co.

Illustration 127. Showing taping of veneers with pregummed tape, using electric drying attachment. Pressure releasing levers are convenient for each operator.

Courtesy, New Albany Veneering Co.

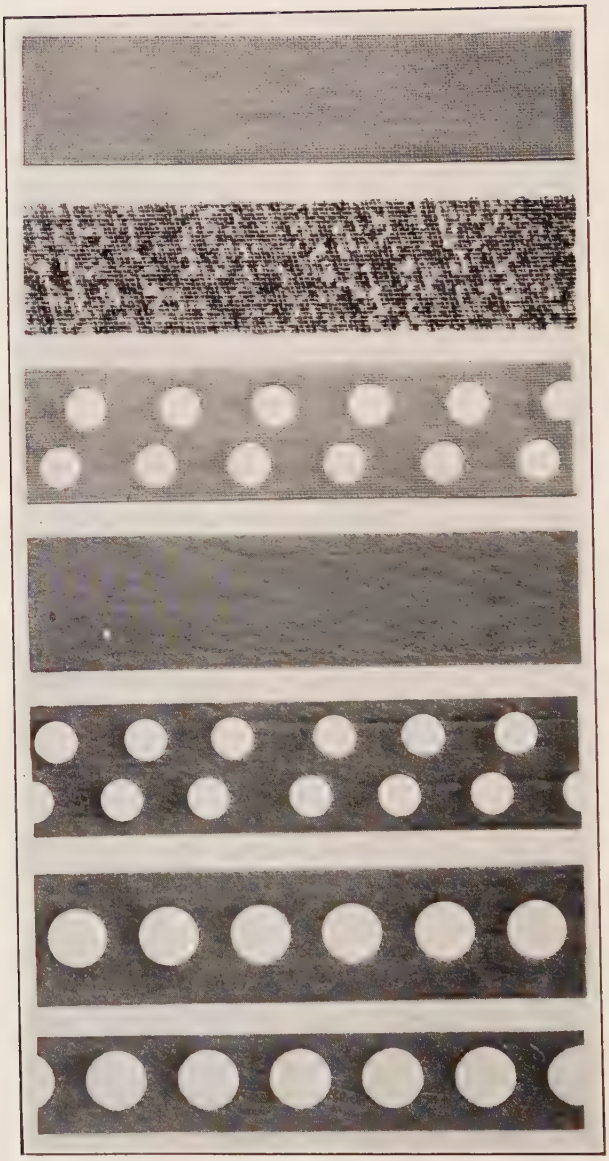

Illustration 128. Showing types of veneer tape, solid and perforated, made from cloth and from paper.

Courtesy, McLaurin Jones Co.

venient size for gluing into plywood is approximately 2 feet by 4 feet, and smaller units are frequently made "two-on," "three-on," "four-on," or in even larger multiples. These are not cut apart until the final trimming of glued plywood stock.

A typical taping machine is shown in Illustration 127. It may be noted that the operator at the right is crowding two sheets of veneer together by hand pressure. The rollers under which the veneer first passes are "canted" towards each other, forcing the veneer edges tightly together. The gummed tape comes down from rolls above, and is moistened by means of revolving rollers operating in warm water, after which it is pressed down onto the two sheets of veneer by a wide crowned roller. The jointed edges are thus brought together and held in close juxtaposition by means of converging rolls. The pressure roller is heated by means of a gas jet, or by an electric heater and this artificially heated roller, pressing upon the tape immediately sets and dries the glue. The off-bearer, standing at the left, breaks the tape between sheets of taped veneer and inspects the resulting joint. If, for any reason, the workmanship appears imperfect, the tape is torn off before the glue is set too hard, and the sheets of veneer are passed back for retaping, or rejointing, or both, as the case may be.

It is the practice in some factories not only to tape the jointed edges together, but to tape the ends of the veneers, as well, to serve as protection against splitting in handling.

Varieties of Tape. Tape is made of cloth or Kraft paper, of various widths and thicknesses, some is solid, some is perforated, and it is usually pregummed, although occasionally it is gummed in the taping machine. An assortment of tapes is shown in Illustration 128. Paper tape, approximately 1 inch wide, .002 inch thick, is considered good average practice. The advocates of pregummed tape claim that applying the glue on the taping machine is "mussy" and uncertain in its results. The advocates of applying fresh glue by rollers at the taping

machine assert that they secure a tighter joint between paper and wood. Both methods are approved by reputable authorities.

In modern practice, cloth tape is used more for hand application on sample sheets of veneer which are to be used for demonstration and sale purposes. Veneer ends are so taped, and long samples are hinged in as many places as is necessary for folding and packing in sample trunks.

Perforated tape was formerly used for crossings where it was considered that non-perforated tape might weaken the joint between either crossing and face or crossing and core, the latter being least objectionable. Thin, tough Kraft paper (both perforated and solid) is now quite generally and satisfactorily used for taping cross-banding.

Gluing Edge Veneer Joints. Many plywood manufacturers advocate a special operation to apply glue and cement edges of veneer together under the tape. This is done by folding back the joints after taping, and passing the exposed edges over a small horizontal or vertical glue roller, as shown in Illustration 129. The sheets of veneer are again flattened, the surplus glue scraped or wiped off, and the sheets placed in a cradle shown in Illustration 130. This cradling holds the glued edges together until dry.

Preparation of Backs and Crossings. This is quite similar to the corresponding jointing and taping operations on faces as described. Crossings for standard sizes are cut to dimension by the veneer manufacturer and so purchased by the manufacturer of plywood. It is considered the best practice to use one-piece crossings under the face veneer, wherever possible, leaving the two, or more, taped piece crossings to go under the back veneer. If the halves of a two-piece crossing are of uneven thickness or are not snugly held together with tape, quite often the sunken line of the joint will show through the

Illustration 129. Showing how the jointed edges between sheets of taped veneer are glued. Each taped joint is folded back and glue applied by small glue covered roller. Glued sheets are laid in cradles shown in next illustration.
Courtesy, New Albany Veneering Co.

Illustration 130. Showing cradles in which edge glued veneers are placed to allow glue to harden while taped and glued veneer edges are held together.
Courtesy, New Albany Veneering Co.

Illustration 131. Guillotine veneer cutting machine, of paper cutter type, which clips and joints veneers in one operation. Used chiefly to cut four-piece butt-matched veneer and other work, when exact symmetry in matching is required.

Courtesy T. W. & C. B. Sheridan Co. and Berkey & Gay Furniture Co.

face veneer after the outer surface of the completed plywood is finished and polished.

Jointing and Taping Veneer Cores. If cores are 1/12 inch or less in thickness, they will be treated exactly as crossings. Cores 1/8 inch and thicker are usually ripped and crosscut on saws, and are then jointed on veneer jointers and taped on veneer taping machines, in practically the same manner as the thinner veneer. The edges are glued as described and the thickness is sufficient to make a strong joint that will not break easily.

## Crotch and Stump Wood

The procedure for sizing and matching crotch and stump veneers, two-piece side- and end-matched, or four-piece side- and end-matched, is quite a different problem. Craftsmanship (only skilled workmen can be used on this job) demands that chief emphasis be placed on choice of figure, and that here, saving of waste be regarded as secondary. It requires an experienced and trained perception and imagination to visualize the most effective way to select each sheet and then to produce artistic results from a flitch of stump walnut veneers. The procedure of making a four-piece side- and end-matched face will be followed through, as it embraces all the operations involved in producing two-piece side-matched and two-piece end-matched. The mechanical method of making faces from crotches is so similar to the stump process that the steps will not be repeated, although the artistic results of crotch wood are very different from those of stump wood.

Guillotine Cutting Machine. After suitable flitches have been selected, the all-important step is to make right angle face joints, exactly 90°, without tearing, splitting or breaking the exceedingly fragile end-grain veneer. Clippers and saws are both unsuited for this delicate work. The so-called guillotine cutting machine, designed originally for paper

cutting, with carefully adjusted right angle and parallel side and back gauges, adapts itself quite satisfactorily to this most particular and exacting veneer cutting. (See Illustration 131.) A package, or book, of four, eight, twelve, sixteen or more adjacent sheets of veneer is clamped in this machine and cut along a predetermined line. The pressure of the clamp above holds the veneer firmly, and the shearing cut produces a smooth edge with no appreciable tearing of edge grain. Fragile veneer must not be too dry at this stage, in fact, some manufacturers moisten it a trifle to toughen the texture. The bottom and top sheets of veneer should be protected, during cutting, by the use of cardboard or waste veneer. When removed from the clamp, the figure in the exposed edge, just cut, is aligned vertically, and the package again inserted in the cutter with recently cut straight edge against the side gauge. If well and thoroughly clamped, the resulting cut will make a perfect right angle with the first cut. The irregular opposite edges and ends are, for convenience sake, cut parallel, with ample trim allowances.

Matching. The following "time-tested and tried" method has come down through generations of use, and is still good practice where factory equipment is not available or for any reason the hand process is preferred.

Two adjacent, but reversed, pieces of veneer are first laid on the table, so that the figure exactly matches, even if ends require further trimming. The outside edges of the pair of pieces are then tacked to the table (with slender bodied tacks and the use of an electric peen hammer) so that the veneer arches up a trifle to force a tight center joint, as shown in Illustration 132. The two pieces of veneer are fastened together at the joint with gummed tape, temporarily held down by weighted bars or tacks. Small tack holes will be entirely concealed by fillers in finishing. When removed from the table after tape glue is dry, two pair (four sheets of veneer) are laid

together, two more, and so on, in double pairs. The double-sized package or book is again taken to the guillotine cutter,

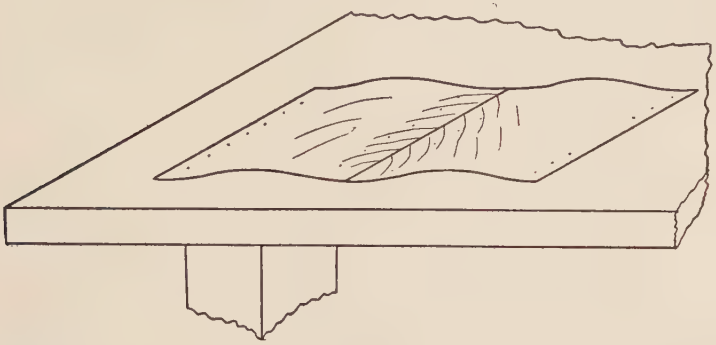

Illustration 132. Showing how edge veneer joints are hand-matched and forced snugly together on table. Tacks to be removed and holes filled.

and the ends (to be further matched and taped together) are then trimmed true and even.

After trimming, each two pairs are laid out flat on the table, tape side up, and a bit of tape torn away at center end of side joint for better observation. The pairs are arched as before to obtain a snug joint, as in Illustration 133. Especial care must be exercised to see that the four-way center joint matches exactly, and that corners are not ragged nor torn. Tape is then glued down and weighted, or tacked, as before. These tapes will be sanded off, after gluing into plywood, so that the surface observed during matching on table will be the final outside face of plywood.

Some authorities advocate end matching first, and side matching second, and undoubtedly some veneer stocks are better handled in that order, but the steps are quite similar to the above.

In most modern plywood plants, stump and butt wood is taped together at the joints by means of the power-operated taping machines as shown in Illustration 127, facing page 214.

Painstaking care must be exercised in laying together the separate sheets, as the slightest variation in grain or figure,

when the various sheets are assembled, means a mismatched and non-uniform design. When each two- or four-piece unit has been accurately matched and assembled, the "sets," as they are

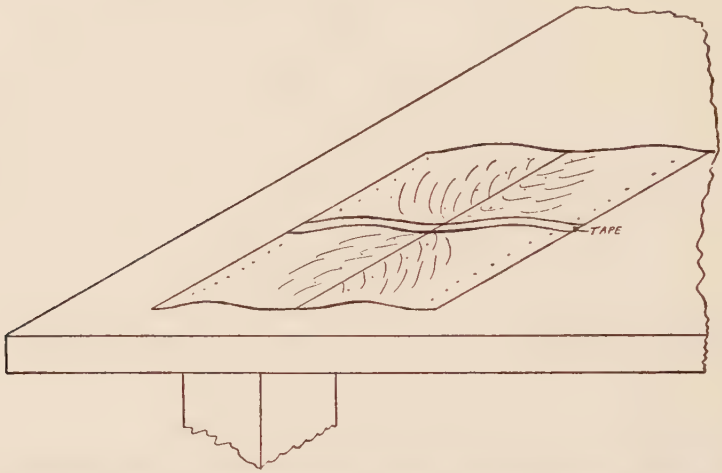


Illustration 133. Showing how end joints (butt joints) are made snug (after side joints have been similarly made and taped), during the hand matching and taping of four-piece faces.

called, are taken to the taping machine. There the sheets of butt or stump veneer are taped together in a manner similar to the taping of ordinary face veneer, except that much greater care must be taken, so that the design and figure in each separate sheet of veneer comes into exact position.

It is of prime importance, after such taping, that there be a perfect and complete match in every sense of the word.

The gluing of veneer edges, under the tape, is practiced on four-piece matching in some factories, in order to prevent an open joint or hair-line in the face veneer under final finish.

## Diamonds, Segments, Miterings and Borders

Diamond-matched veneering is frequently used on door fronts and panels, the mitering extending from corners to cen-

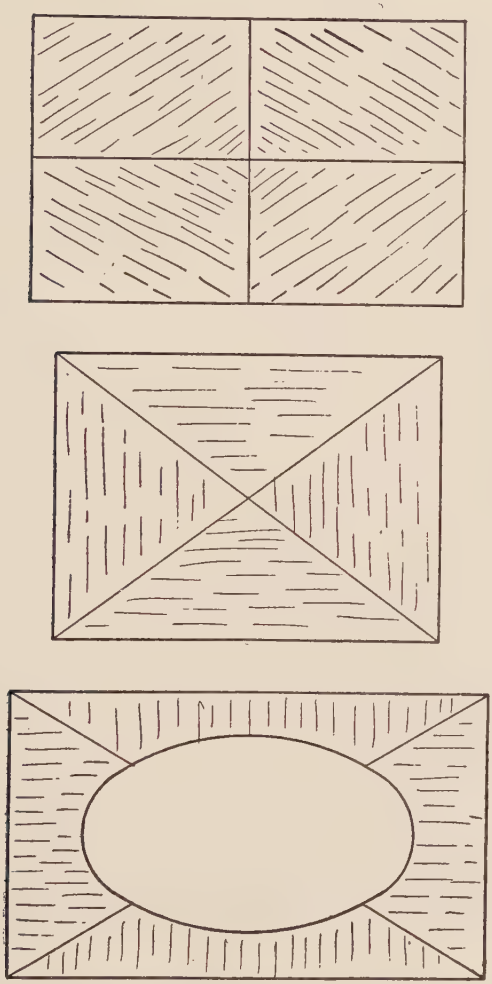

Illustration 134. Showing true diamond-matched design in upper rectangle, and diamond-matched with center oval design in lower rectangle. The center figure is not a true diamond-match, but frequently used in veneered construction.

ter of door or panel. The veneer cutting and matching is done in a way quite similar to the four-piece stump work just described, but the angle varies from 90° sufficiently to cover the oblong surface symmetrically, as shown in Illustration 134. An example of the fine diamond matched four-piece veneer is shown in Illustration 135. The grain usually runs around such a pattern, but may be radial. "High lighting" is often practiced in finishing these diamond effects, with light shading in center increasing to darker shades at outside. The optical effect may be similar to a slightly raised or depressed pyramid. Center medallions are frequently used, since perfect center point matching is most difficult to achieve.

Segmental veneer matching is a variation or refinement of the diamond pattern, with more than four joints, giving a sunburst or star effect. (See Illustration 31, page 80.) Angles have to be most carefully measured, and a trade secret may possibly be revealed; i.e., in the final matching of the last segment, considerable trimming and manœuvering has to be done, usually resulting in one small or large segment that is rarely detected except by the experienced observer.

Border veneering, side grain to side grain, or end grain to side grain, produces the effect of framing, or with shading, of a sunken or raised panel. (See Illustration 79, page 172.) It is entirely a development of the principles outlined in four-piece stump work. In some of the more intricate figures and patterns, practically the whole combination of sheets of veneer, individually and severally, is attached to an entire sheet of gummed paper, since so many overlapping tapes would produce uneven thickness or "piling" for subsequent gluing into plywood.

The routings for inlays and the insertion of marquetry, as well as the applying of appliqués or overlays, will be treated in Chapter XXVIII, since all such ornamentation is accomplished on completely glued plywood.

Illustration 135. Showing diamond-matched, four-piece mahogany veneer.

Courtesy, Berkey & Gay Furniture Co.

# CHAPTER XXI

## VENEER USES OTHER THAN PLYWOOD

Relatively little veneer is used single-ply, although there are certain products in which its use is essential.

### Baskets and Fruit Packages

A large proportion of commercial baskets is made, using rotary cut veneers, excluding, of course, those made from solid and split reeds, as well as those made from grasses and pulp products.

Basket factories are generally local, due to the shipping cost on such bulky and low-priced goods. Therefore, most local woods are used, such as gum, elm, maple, birch, bass and the like. The common bushel baskets and the similarly shaped baskets of larger and smaller capacities, are usually made of veneer, slit into narrow strips, fastened together at a common center, spread out like the rays of a star fish, and finally formed up into a shape rather deeper than semi-spherical, and held in shape by hoops or bands on the outside.

There is a large variety of grape baskets, peach baskets, berry boxes and crate shapes made of curved and bent veneers, often stapled together, sometimes with lumber bottoms, and frequently with wire handles, as shown in Illustrations 136 *a* and *b*.

Boxes and box shooks for citrus fruits, apples, pears, etc., are usually made with lumber ends and partitions, and veneer sides, tops and bottoms, all nailed together.

Butter dishes are made of veneers, stapled at the corners to form proper "dished" shape. Wooden plates for picnic lunch-

eons were formerly pressed from veneer circles, but these are now largely replaced by paper plates.

### Medical and Surgical Uses

Splints of veneer, band-sawed and with ends rounded, are easily bent into stiff semi-cylindrical shapes and are used for supporting and straightening broken bones.

Spatulas are punched out of 1/16 or 1/20 inch veneer for use in examining throat and mouth cavities.

### Protective Coverings for Cans and Barrels

Cylindrical wooden containers, or drums of various sizes have been made to compete with the smaller sizes of slack barrels.

Tin cans, both round and rectangular, of 1 to 10 gallon capacity, require for shipping purposes a protective casing of veneer, to prevent the denting, bending and puncturing of the tin. Such a casing gives adequate protection without adding materially to the weight.

### Wrapping Leather

Leather cannot, without injury, be folded or creased. Elm veneer, 1/20 inch thick, is tough and makes an admirable protective wrapper, in which to roll a few hides for shipment. The veneer though light, amply protects the leather from bruising and at the same time maintains the package in cylindrical shape.

### Furniture Uses

Furniture manufacturers use relatively thick single-ply veneers for drawer bottoms, mirror backs, protective dust bot-

Illustration 136*a*. Showing two types of baskets made from veneer, bent and nailed together, instead of glued as in plywood.

Courtesy, Eastern States Package Co.

Illustration 136*b*. Showing other types of baskets made from veneer, bent and nailed together, instead of glued as in plywood.

Courtesy, Eastern States Package Co.

toms, case backs, and the like. In better grades of furniture, 3-ply veneer is preferred to single-ply.

Filing cases and transfer boxes often have veneer sides and bottoms, with or without cloth or paper covering, the veneers being nailed to lumber ends. Trunk partitions are sometimes of single-ply veneer, cloth covered.

# CHAPTER XXII

## STORAGE AND SALE OF VENEER

### Storage Rooms

Rooms should be medium dry, not too hot nor too cold, equipped with flat dry floors, as well as with substantial racks or shelves on which to pile figured woods several layers or tiers high. A dry basement is desirable, although small platforms or bases should be provided to protect the lower sheets from damage. Lofts are usually too dry. The ideal to be desired is an atmospheric condition such that veneers dried to approximately twelve to fifteen per cent moisture content will not give off nor take on moisture. Such veneer will be reasonably pliable, and breakage will be reduced to a minimum. Stocks are usually piled solid, so that sheets are kept flat and true, without wrinkling or checking.

Veneer, piled otherwise, will crinkle, check and tear, producing serious deterioration and loss of value.

The storage of plain veneer presents quite a different problem from that of figured wood.

### Figured Wood in Flitches

Figured and face woods, when cut into veneer, are kept as complete flitches, and often the adjacent flitches of a stump, crotch, or log are kept together, since similarity of figure will augment considerably the possibility of advantageous matching. Every flitch is marked somewhat like this:

# 7631 B
2354 ft.
1—3

There is, however, considerable variation in marking among the different cutting mills. The first number usually designates a serial number given to each flitch as it is cut into veneer. "B" indicates the second flitch cut from the same log, the former having been designated as "A." The center figures indicate total area by scale measurement. The basis of this measurement varies in different woods, but usually in figured woods, allowance is made for obvious defects, and frequently for sap or light-colored wood. The number in the bottom line appears only on sample sheets and in this case indicates the top sample sheet; 2-3 would indicate second sample sheet; 3-3 the next, and so on. Most flitches are sampled three times, top, center, and bottom, but conditions may require four or five samples, where either figure or dimension changes radically. The sheets in some flitches are numbered consecutively when cut, 1, 2, 3, etc., to permit correct reassembling of sheets after drying, but this is rarely necessary.

Flitches are kept in prime condition when piled flat and solid on the floor, or are stacked up with solid flat wooden bases under each flitch, as shown in Illustration 137. Small units can be piled on top of the larger, providing, however, they are always kept flat. Every flitch should be tagged and marked for number and footage.

Flitches that have been crated for shipment can sometimes be piled up if bottom board of crate supplies a flat, even base. Usually, however, flitches are uncrated, sometimes verified for measurement or rescaled, and repiled in an orderly manner.

Samples are marked as previously described, and kept in exhibition racks, frequently classified for similar figure, color, price, or other grouping. Purchases and sales are usually made from such typical samples. The veneer salesman usually has large sample trunks, into which veneer samples can be folded, after hinging with cloth. Edges and ends are often cloth bound or reinforced to prevent breaking in frequent handling.

Samples are also used by the plywood manufacturer to se-

lect his own flitches for certain customers or to plan the cutting of orders, or to designate the typical character or figure to be chosen for a certain line of product.

The serial numbers, footage and value of flitches are usually recorded in a book or on indexed cards until checked out.

In the case of quartered oak veneer, samples are rarely taken, as the degree of quartering varies so greatly. The marking of oak usually includes serial number of flitch, footage area, average width and length, and frequently total width, when laid out open, and quantity of sheets.

Some figured woods, such as bird's-eye maple, curly birch, etc., are rotary cut, each complete circumference of the log being considered a sheet. These are usually numbered and designated as first described, and while constituting a complete log, are treated as a flitch.

## Plain Unfigured Veneer

The figured woods above are usually cut to reveal figure, and rarely for size. Plain woods are almost invariably cut to standard or special lengths and widths. One series of standard sizes is for stock panels, widths usually stepping up by 6 inch intervals and lengths by 1 foot sizes.

| Length | | Width | Length | | Width |
|---|---|---|---|---|---|
| 36 | x | 24 | 60 | x | 24 |
| 36 | x | 30 | 60 | x | 30 |
| 36 | x | 36 | 60 | x | 36 |
| 48 | x | 24 | 72 | x | 24 |
| 48 | x | 30 | 72 | x | 30 |
| 48 | x | 36 | 72 | x | 36 |

Other series may be for door sizes, furniture requirements, piano specifications, etc. Sizes are usually cut 2 inches large each way to permit final trimming to sizes shown.

Illustration 137. Showing veneer stock room with mahogany veneer in crates and in piles.
Courtesy, Fuller Thurber Co.

Face veneer is usually crated 1,000 feet to a crate, or 50 sheets, or some other convenient multiple. The attempt is made to have half of the pieces in each crate "one-piece" for faces, and the balance "two-, three-, or four-pieces," for backs.

Crossings have the grain in opposite direction and are sometimes bundled or strapped in large packages, but usually they are crated.

Sheet veneer for faces and backs, or for cross-bands, should be piled down flat, and in as high piles as can be conveniently handled. Stock thus allowed to temper and flatten is more highly prized for gluing than stock that is left in crates or piled on racks. The weight of the pile keeps the sheets straight, and often remedies the wrinkly effect of drying.

Dealers who handle a jobbing business often keep veneers in crates for convenience in handling and shipping, but consumers usually wish to stack in piles before using. The longer the veneers remain in stacks or piles, the flatter they become. They are, therefore, more easily used without buckling and splitting.

Crates are clearly marked with contents and sometimes serially numbered.

## Face Veneer Sample Rooms

The method of selecting and marking sample sheets from each flitch has been described.

The experienced salesman chooses a room with medium light, often the milder north exposure is desirable. Too bright a room fails to show the contrasting and subtle shades of figure and texture. Choice and valuable figured veneer samples are carefully located with particular reference to light exposure.

Veneer samples are usually arranged or sorted in piles for color, grade, price, etc. The purchaser frequently makes his selection in two, three or more piles, first choice, second choice,

undesirable, etc. After inspection and selection, total footage and prices are computed, and a lump sum price usually agreed upon for an entire lot.

Plain, unfigured woods, except walnut and mahogany veneers, are seldom sampled and are usually sold on grade without inspection.

The successful veneer salesman is clever and ingenious in making an attractive demonstration of his merchandise.

Large plywood factories often have their own veneer sample show rooms, both for demonstration to customers and for intelligent allocation of veneers to orders. The extremes of making either too "rich" or too "plain" plywood must be carefully avoided.

# CHAPTER XXIII

## PLYWOOD ASSEMBLY, DEFINITIONS AND OUTLINE

### "Ready to Lay"

Assembling the various dry wood and veneer layers and liquid adhesives into proper form and having all ready at one time and in one place, is one of the problems that makes a plywood production man a most necessary individual, and one that requires careful planning, co-ordination and accurate daily production records.

The veneers, faces, crossings and backs, have been made "ready to lay" in previous chapters, but the necessary lumber cores are yet to be made, and the adhesives must be well understood to mix and apply them intelligently. If the cores are to be of veneer, the only lack is the information about glue.

While veneers are waiting to be glued into plywood, it is desirable to store them in a warm dry room, where they lie as flat as possible on trucks, the crossings usually in one or two piles (if distinction is made between face and back crossings) with the faces and backs usually alternating and in the relative order and position they will occupy in the final plywood.

### Laminations or Plies

The term plywood has been accepted by the producing trade to provide a brief descriptive title that distinguishes the glued or built-up laminated product from its component single sheets. While the term plywood, as used in this book, indicates rather

recent practice in this country, yet it will be found that it has been in common use in Great Britain and on the Continent for some years.

Strictly speaking, a "ply" refers to a fold or doubling of thickness and by usage is modified to describe flat layers or strands of rope or wire.

Laminated veneer may be 2-ply, 3-ply, 4-ply, and so on, but commercially is usually 3-ply or 5-ply, the increased number of plies being an indication of increased strength and better quality. Balanced stresses and flatness are lacking in 2-ply construction, although it is used somewhat for mirror backs, dust bottoms, and packing shooks. Four-ply and 6-ply are seldom used. An uneven number of plies such as 3-, 5-, or 7-, permits equalized internal stresses, while at the same time providing for a strong durable core, with desired quality of face and back, interleaved if considered necessary with crossings or cross-banding.

In 3-ply, the grain of face and core are at right angles, placing the strength elements perpendicular to the face grain, which is not always desirable. Placing the three layers with grain parallel will not make flat plywood because stresses are unbalanced.

In 5-ply, face, back and core grain are parallel and crossings at right angles. Small core imperfections will not ordinarily show through crossings to faces and the strength element is like a solid board, but with counterbalanced internal stresses due to cross-bandings.

The use of 7-ply is relatively rare except for special construction, since 5-ply gives abundant strength and balance. Equal thicknesses and alternating direction of grain are sometimes built up for especial strength or resistance qualities, as in airplane work, disc wheels, bent work and the like.

Plies laid together with grains at angles of 30°, 45°, 60° and the like will not result in flat plywood since internal stresses are out of balance.

## Definitions

During the development of the term plywood and the growth of the industry, no very sharply drawn descriptive distinctions have been made between the different kinds of plywood, nor between the combined use of layers of veneer and lumber as compared with the exclusive use of plies of veneer.

The Forest Products Laboratory, maintained by the United States Government at Madison, Wisconsin, has attempted to draw rather close technical limits on the various kinds of veneered products, as stated in Chapter XII:

> *Laminated wood,* refers to constructions in which two or more layers of wood are fastened together with the grain of all plies or laminations parallel.
>
> *Cross-banded veenered panels,* refers to glued material with veneer faces, veneer cross-bands and a lumber center or core.
>
> *Plywood* is used to describe a combination of several plies or pieces of veneer glued together usually so that the grain of any one ply is at right angles to the adjacent ply or plies.

The present trade designations are even less distinctive than the technical group, above, i.e.:

> *Panels,* referring particularly to 3-ply veneer construction, in which face, back and core are all veneer. This usually includes as well 5-ply, when all layers are of veneer.
>
> *Tops,* this term comes from the use of 5-ply veneer faces and crossings, with lumber core, for table, bureau, commode, desk and counter tops, and is quite generally so understood. Top construction may also describe doors, drawer fronts, bed and cabinet ends, and the like, so long as they are so made. It is also used in referring to 3-ply tops, where the crossings are eliminated.

Neither group of subdivisions is sufficiently comprehensive, since some manufacturers will choose a 5/16 or 1/4 inch veneer core, and some a resawn lumber core, to use as a base for the same 7/16 inch plywood product. It does not clarify

the issue if one manufacturer calls the similar resulting product by one name and another manufacturer uses a different designation. The definitions are more fully discussed on page 112.

However, the use of the term *plywood* in a comprehensive sense seems to have gone too far to draw the narrow limits suggested by the Laboratory, and the present trade usage is not sufficiently exact to entirely clarify the issue. The word *plywood* [1] is used as applying to all glued up veneered stock, and the terms tops and panels avoided as much as possible.

The designations used throughout this book are, therefore, described as follows: ply, core, face, back, crossing, edge, dimension etc. This would result in the following arrangement of plywood specifications:

5-ply lumber core—veneer face, center matched, reject back, one-piece face crossings, veneered edges, size 24″ Wide x 48″ Long x 13/16″ Thick.

or

3-ply veneer core—veneer face selected for color, sound back, 15″ Wide x 60″ Long x 1/4″ Thick.

## Laminated Wood or Compound Lumber

Several layers of sawed boards, glued together without veneered layers, are also sometimes called plywood construction. This type of lamination is used to make legs, pedestals, columns and the like where lumber of sufficient thickness is difficult to obtain or to kiln dry. Such laminations of lumber (without variations in grain direction) are obviously stronger, as well as more stable, and unchanging, and in other words, less liable to internal stress and strain than solid one-piece wood of the same aggregate thickness.

[1] During the preparation and publishing of this volume, the Plywood Manufacturers' Association has developed a definition as stated in full on page 112.

# CHAPTER XXIV

## LUMBER CORES AND THEIR PREPARATION

Most of the better grade plywood consists of figured face veneers mounted on a lumber core or base with 5-ply crossbanded construction. It is of fundamental importance that this lumber core be properly prepared so as to furnish a smooth, sound, level and durable base for the thin and somewhat fragile veneer. The parable of the house built upon the sands applies with equal effectiveness to gluing of veneers upon an unstable base.

### Economical Lumber Grades

The choice of lumber, as to species and grade, varies with the quality of the product and the individual preferences of the purchaser and manufacturer. Chestnut and poplar are almost universally used core woods, since they are easily worked, react favorably to gluing procedure, are reasonable in price, and less liable to warping and dimension changes than many other woods. Gum is quite extensively used in localities where its cost permits, and is regarded by many as equivalent to poplar, being somewhat more dense and taking a better finish, but requiring more careful drying treatment. Many other woods are used, such as birch, maple, basswood, oak and the softwoods, depending on the ultimate use, local availability and comparative cost.

Authorities are by no means agreed as to the most desirable grades of lumber to use for core building, some manufacturers claiming more economical results from the use of higher grade

and higher priced lumber, which requires less handling and from which cores may be produced with a lower waste factor, while others are equally confident that eventual cost savings are achieved by the use of the cheaper and medium grades of lumber, in spite of the larger waste percentages and increased handling. No fixed rule can be established that will satisfactorily govern all conditions. Each manufacturer can, however, carefully determine the net cost of his lumber core stock "ready to lay," and by trial and experiment satisfy himself that his procedure is most economical under existing conditions. The fluctuating prices of lumber frequently change the controlling conditions, the higher grades of lumber are in greater demand, and the lower grades are difficult to market, resulting in a better ratio between utilization value and price in the medium and lower grades. It is, however, a significant and a noteworthy fact that plywood construction, using lumber cores, has created a large demand for the lower and otherwise less valuable grades of various woods and, in this particular, the increasing use of plywood will serve as an important aid to the conservation of our rapidly diminishing forest product supply.

## Drying in Kilns

The reasons for kiln drying are many, but the chief, and no doubt the most important, reason for the kiln drying of both lumber and of veneer, is that until the process of kiln drying has taken place, there remains in the wood product a certain amount of sap and sap moisture, and until this natural wood content is thoroughly dried out and removed by means of air drying and kiln drying there is always a tendency to internal stress, causing warping, twisting and winding, thus making the non-kiln dried product unsuitable and undesirable for cabinet, furniture or plywood use.

Lumber at moisture content percentages between three and seven per cent (based on dry fibre weight) is practically un-

changing in dimension, i.e., does not shrink nor swell perceptibly, and is also atmospherically normal. In other words, lumber so dried will not exceed that range of absorption or evaporation of moisture, in the ordinary temperature and humidities of factory workrooms, or suitable storerooms for dry lumber stock in process, or completed but unfinished (i.e., "in the white") wood work.

Products, made from lumber between the above limits of moisture content, should finally have all exposed surfaces finished (with oil, shellac, etc.) as unfinished surfaces may change with atmospheric conditions.

It is regarded as commercially impracticable in this country to attain this degree of dryness by air drying alone, although the practice is not uncommon in England and on the Continent, where several years can be allowed for thorough air drying.

Drying direct from the saw is possible, but not generally accepted as an economical procedure. There are instances where it has been conspicuously successful, but the amount of plant investment necessary and the kiln drying skill and experience required, have prevented its extensive adoption.

Theory of Kiln Drying. When reduced to its simplest terms, all lumber drying is a process involving the conversion, from liquid to vapor, of the fluids contained in the cells of the wood, and after such conversion, the circulation and removal of the air carrying this vapor, and the substitution of more dry air to continue the cycle of vapor lifting and removal.

The above is the underlying principle, whether the drying takes place at or near freezing temperatures or approaching the boiling point, either out-of-doors by means of nature's sun and wind, or in the kiln by artificial heat and circulation. Keeping this principle clearly in mind will be of great aid in further visualizing its application to each drying problem.

The moisture carrying capacity per cubic foot of air varies with the temperature substantially as follows:

| Temperature Fahrenheit | Water Vapor per Cubic Foot Air at Saturation | Temperature Fahrenheit | Water Vapor per Cubic Foot Air at Saturation |
|---|---|---|---|
| 50° | 4.08 grains | 130° | 44.09 grains |
| 60° | 5.75 | 140° | 56.41 |
| 70° | 7.98 | 150° | 71.51 |
| 80° | 10.94 | 160° | 89.76 |
| 90° | 14.72 | 170° | 111.71 |
| 100° | 19.76 | 180° | 137.89 |
| 110° | 26.11 | 190° | 168.85 |
| 120° | 34.11 | 200° | 205.37 |

In brief, air at 100° will carry nearly five times as much water as at 50°; and at 150° almost eighteen times as much as at 50° and over three and one half as much as at 100°.

The homely practices of laying wet mittens on the register, or setting wet shoes under the stove, or hanging a wet towel over the radiator, are familiar expressions of this scientific fact. Heat rapidly increases the capacity of the air for carrying moisture, and if any amount of drying is to be done, the moisture laden air must be moved away and dryer (and usually cooler) air supplied to continue the cycle of drying. Drying capacity, under any degree of heat, ceases when air becomes saturated, and fresh unsaturated air is necessary to continue drying. No closed room, without air changes, can serve efficiently as a drying unit for any material.

The application of this method of measurement (moisture carrying capacity of air) to kiln efficiency is scarcely developed as yet. An extension of saturated air tables into graduated relative humidities (or percentages of air saturation) within the range of usual kiln operation, is given in the accompanying table.

The drying power, expressed in grains per cubic foot of air, varies with temperature and amount of saturation, as a study of the table will show. Drying power also varies with the moisture deficit (practically the reciprocal of saturation), or the amount of vapor required to bring a cubic foot of air up to saturation. To consider drying power and moisture deficit

CAPACITY OF AIR FOR CARRYING MOISTURE

In grains per cubic foot

(7000 grains = 1 pound avoirdupois)

| Relative Humidity Per Cent | Temperature in degrees Fahrenheit | | | | | | | | | | | Reciprocal of Relative Humidity Per Cent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 120 | 125 | 130 | 135 | 140 | 145 | 150 | 155 | 160 | 165 | 170 | |
| 5% | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 6 | 95% |
| 10% | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 8 | 9 | 10 | 11 | 90% |
| 15% | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 15 | 17 | 85% |
| 20% | 7 | 8 | 9 | 10 | 11 | 13 | 14 | 16 | 18 | 20 | 22 | 80% |
| 25% | 9 | 10 | 11 | 13 | 14 | 16 | 18 | 20 | 22 | 25 | 28 | 75% |
| 30% | 10 | 12 | 13 | 15 | 17 | 19 | 21 | 24 | 27 | 30 | 34 | 70% |
| 32% | 11 | 13 | 14 | 16 | 18 | 20 | 23 | 26 | 29 | 32 | 36 | 68% |
| 34% | 12 | 13 | 15 | 17 | 19 | 22 | 24 | 27 | 31 | 34 | 38 | 66% |
| 36% | 12 | 14 | 16 | 18 | 20 | 23 | 26 | 29 | 32 | 36 | 40 | 64% |
| 38% | 13 | 15 | 17 | 19 | 21 | 24 | 27 | 31 | 34 | 38 | 42 | 62% |
| 40% | 14 | 16 | 18 | 20 | 23 | 26 | 29 | 32 | 36 | 40 | 45 | 60% |
| 42% | 14 | 16 | 19 | 21 | 24 | 27 | 30 | 34 | 37 | 42 | 47 | 58% |
| 44% | 15 | 17 | 19 | 22 | 25 | 28 | 31 | 35 | 39 | 44 | 49 | 56% |
| 46% | 16 | 18 | 20 | 23 | 26 | 29 | 33 | 37 | 41 | 46 | 51 | 54% |
| 48% | 16 | 19 | 21 | 24 | 27 | 31 | 34 | 39 | 43 | 48 | 54 | 52% |
| 50% | 17 | 20 | 22 | 25 | 28 | 32 | 36 | 40 | 45 | 50 | 56 | 50% |
| 52% | 18 | 20 | 23 | 26 | 29 | 33 | 37 | 42 | 47 | 52 | 58 | 48% |
| 54% | 18 | 21 | 24 | 27 | 30 | 35 | 39 | 43 | 48 | 54 | 60 | 46% |
| 56% | 19 | 22 | 25 | 28 | 32 | 36 | 40 | 45 | 50 | 56 | 63 | 44% |
| 58% | 20 | 23 | 26 | 29 | 33 | 37 | 41 | 47 | 52 | 58 | 65 | 42% |
| 60% | 20 | 24 | 27 | 30 | 34 | 38 | 43 | 48 | 54 | 60 | 67 | 40% |
| 62% | 21 | 24 | 27 | 31 | 35 | 40 | 44 | 50 | 56 | 62 | 69 | 38% |
| 64% | 22 | 25 | 28 | 32 | 36 | 41 | 46 | 52 | 57 | 64 | 71 | 36% |
| 66% | 23 | 26 | 29 | 33 | 37 | 42 | 47 | 53 | 59 | 66 | 74 | 34% |
| 68% | 23 | 27 | 30 | 34 | 38 | 43 | 49 | 55 | 61 | 68 | 76 | 32% |
| 70% | 24 | 27 | 31 | 35 | 39 | 45 | 50 | 56 | 63 | 70 | 78 | 30% |
| 72% | 25 | 28 | 32 | 36 | 41 | 46 | 51 | 58 | 65 | 72 | 80 | 28% |
| 74% | 25 | 29 | 33 | 37 | 42 | 47 | 53 | 60 | 66 | 74 | 83 | 26% |
| 76% | 26 | 30 | 34 | 38 | 43 | 48 | 54 | 61 | 68 | 77 | 85 | 24% |
| 78% | 27 | 31 | 34 | 39 | 44 | 50 | 56 | 63 | 70 | 79 | 87 | 22% |
| 80% | 27 | 31 | 35 | 40 | 45 | 51 | 57 | 64 | 72 | 81 | 89 | 20% |
| 85% | 29 | 32 | 37 | 43 | 48 | 54 | 61 | 69 | 76 | 86 | 95 | 15% |
| 90% | 31 | 35 | 40 | 45 | 51 | 58 | 64 | 73 | 81 | 91 | 101 | 10% |
| 95% | 32 | 37 | 42 | 48 | 54 | 61 | 68 | 77 | 85 | 96 | 106 | 5% |
| 100% | 34 | 39 | 44 | 50 | 56 | 64 | 72 | 81 | 90 | 101 | 112 | |

Courtesy *Wood Working Industries*

as synonymous terms is confusing and the former is more descriptive. It is seldom that complete drying power can be realized in practice, as the tendency of nearly dry air to absorb is more rapid than that of nearly saturated air, hence higher humidities absorb slowly, and are often useful in retarding too rapid drying.

With this outline of basic drying principles, it is possible to proceed to consider the essentials of efficient artificial drying of lumber in present-day dry kilns. The successful operation of any lumber kiln depends on control of temperature, of relative humidity of the air, and of circulation or ventilation.

Wet and Dry Kiln Drying. There are two generally used methods for the drying of lumber, the wet and the dry, odd as the statement may appear. The surface of lumber always dries faster than the interior, and this variation in speed develops much of the internal stress and strain that causes lumber degrade. The moisture from the center of the board works out through the drier surface layers with considerable difficulty, and maintaining the surface layers in damp condition, facilitates the removal of the center moisture.

The advocates of the dry method do not steam nor spray as part of the drying operation, but endeavor to draw the central moisture through the drier surface. They contend that any introduction of water in spray form increases the amount of vaporization to be done. But they have to admit that a dry surface retards the drying operation (somewhat as blotting paper when dry is less efficient as an absorbent than when partly moist) and that internal strains are difficult to prevent.

Those who believe in the wet method contend that steaming the lumber as a preparation to drying has a tendency to dissolve and dilute the cell contents, making them easier to remove, to equalize the surface dryness with the interior moisture, and to maintain an easier path outward for the internal center moisture.

Both theory and practice seem to favor the advocates of the wet method, as the energy required to evaporate the additional moisture is more than offset by the greater speed, the reduction of internal strain, and the higher temperatures which can be safely used, with accompanying high humidities.

Three Types of Kilns. The three main divisions into which lumber kilns may be grouped, as shown in Illustration 138, are:

*Blower:* Mechanically forced ventilation or recirculation, whether suction or plenum method; moisture-laden air usually discharged out-of-doors.

*Condenser:* Generally of the gravity-recirculating type in which the air passes over moisture-removal or condensing units, once in each air interchange.

*Ventilated:* Fresh air taken in and used air discharged direct from kiln atmosphere, utilizing the fundamental laws of physics to obtain internal circulation.

To understand the particular range of each of the foregoing types, it is necessary to outline the moisture-removal problem, from the standpoint of the lumber to be dried. Air drying (usually preliminary to kiln drying) removes more moisture from the surface than from the center, and because of the length and width of a board, drying takes place chiefly through the flat faces, rather than through the ends or edges. The inevitable result is a surface, drier than the interior, and air-dried stock is, therefore, subject to an internal strain that often manifests itself in the form of warp, twist or other surface irregularities. The problem is to draw the center moisture out and leave the surface and interior equally dry.

It is obvious that if the drying of wood afforded no organic difficulties, the blower would dry rapidly, utilizing considerable power, and the condenser would function slowly but at a lower cost. The ventilated kiln is the most generally used,

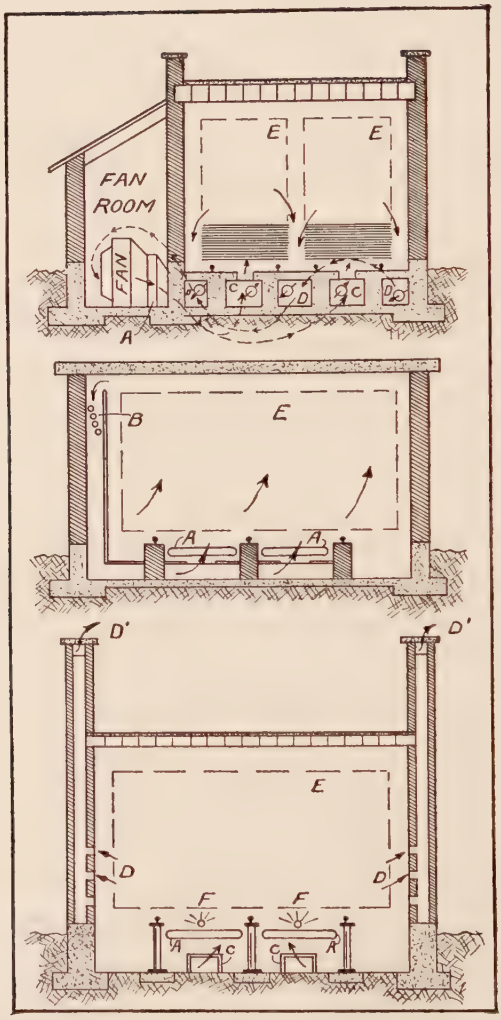


Illustration 138. Showing types of lumber drying kilns, *blower* above, *condensing* in middle, and *ventilated* below.

Courtesy, *Wood Working Industries.*

and providing it is efficiently designed and its underlying principles are followed, its use results in speed and economy.

The nature of wood is the phase of the problem that is least understood. The fibres of the wood should not undergo external or internal strain during drying, but it is practically impossible to maintain such a "strainless" condition. The reduction of this drying strain to a minimum point is necessary to drying without damaging the lumber, the usual manifestations of which are checking, warping, "honey-combing," "hollow-horning," etc. The chance of internal strain greatly increases with the thickness of the wood to be dried; i.e., 1/16 inch veneer is practically all surface and can develop little internal strain in any kind of drying, while 4 inch green oak presents a very stubborn drying problem.

Blower Type of Kiln. These facts lead to the logical conclusion that where thickness is nominal, as in the case of veneer, the speed of the air movement in a blower kiln will remove moisture rapidly and cause no serious damage; but where thickness becomes appreciable (1/2 inch and up), the rapidly moving atmosphere of a blower kiln is liable to produce uneven drying and unnecessary interstrain which will damage the lumber.

Condenser Type of Kiln. On the other hand, the slowness in operation of the condensing kiln will make for accurate control, but the lack of speed may force the initial cost of installation to an excessive amount. As a matter of fact, experts frequently have recommended the condensing kilns, without always comprehending the economic aspect. An instance was noted where kilns of the condensing type, used for war work, did no better drying than the best of the ventilated types and required, for an equivalent output, practically twice as many units, at approximately double the initial cost per unit, or in other words, a quadruple investment, with no appreciable gain in quality or safety.

Ventilated Type of Kiln. Ventilated kilns may be grouped into three classes—with air outlets at top, side and bottom. Some of the generally adopted and better-known designs will be described, and their principles outlined (see Illustration 139), even though their trade names cannot be used.

The number of air interchanges per hour should not be too great. If an anemometer test shows three or four complete air changes per hour, such is sufficient. The process of the withdrawal of water vapor from the hollow spaces in the lumber must not be excessively rapid. Too rapid air movement in a ventilated kiln subjects it to the same criticism as a blower kiln, i.e., too rapid surface-drying.

Kilns of the first class are ventilated at the *top,* either through the ceiling and cupola on the roof, or through openings in the side walls near the ceiling. Fresh air is usually admitted near the floor and the air movement must be distinctly upward. The real problem is to obtain an efficient utilization of the air movement to lift moisture up from the lumber and out through the outlet.

The second class have air exits in the *sides,* and air inlets usually at the bottom. There is less scientific basis for this type than for either the first or the third type. There is danger of "short circuiting" the air across a corner of the kiln, thus causing pockets in places where a lack of air movement prevents drying. When (to reduce shipping weight at sawmills) this type is applied to the primary drying, by means of high temperatures, it will give satisfactory results.

The third type, often called "reversed" ventilation, has a downward circulation with outlets at the *bottom.* The fresh air inlets are at or near the ceiling line and the damp air exits are in the pit below the lumber. This method adapts itself most effectively to the handling of heavy, moisture-laden air, shown to be necessary to dry the lumber uniformly. Whenever any portion of the atmosphere of the kiln acquires a substantial amount of moisture, it will lose temperature, increase in weight

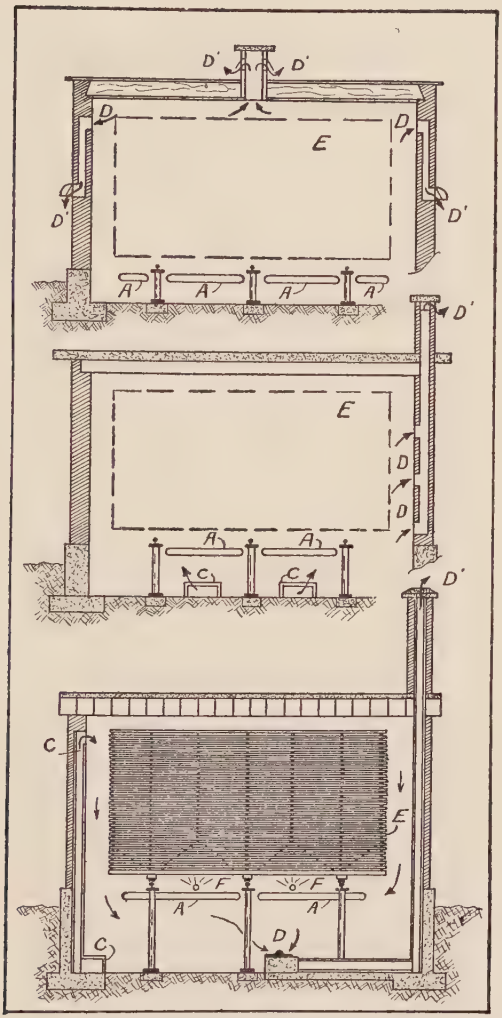


Illustration 139. Showing classes of ventilated kilns; *top* outlets in upper section, *side* outlets in middle section, and *bottom* outlets in lower section.

Courtesy, *Wood Working Industries.*

and settle. Heavy air that has settled into a pit will not readily be drawn up a stack. Steam-heated pipes in the stacks will accomplish this and at the same time keep the water vapor from condensing on the interior of stacks or at the top of outlets. For high grade work, this type affords reliable regulation of the three essentials, temperature, humidity and circulation.

Mechanical Handling. Handling the lumber between the incoming railroad car and the kiln should be done mechanically as far as possible. Lumber yards on wheels are gradu-

Illustration 140. Showing unnecessary lumber handling between railroad car and dry kiln.

Courtesy, National Dry Kiln Co.

ally proving their worth, since they provide for the direct piling of lumber from railroad to kiln car, thus eliminating many expensive handlings. Intermediate air drying, if necessary between receipt of lumber and kiln drying, can be better accomplished when lumber is piled on kiln trucks using sticks at uniformly close intervals than with the usual dead piling of the conventional sort. Illustration 140 graphically shows the possible labor simplifications by the introduction of mechanical handling. A typical lumber yard, arranged with complete trackage connections, is shown in Illustration 141, although the space for air drying of lumber could be advantageously increased.

Piling Lumber for Drying. Unless lumber is properly piled to enter dry kiln, it will not come out straight, evenly dried and free from kiln defects.

Illustration 141. Showing arrangement of lumber yard on wheels, with dry kilns in the background. Railroad siding between factory and lumber yard.

Courtesy, Berkey & Gay Furniture Co.

Circulating air, with a moisture deficit of appreciable amount, is essential to any form of lumber drying. When such air (below the vapor saturation point) comes in contact with the boards, it will tend to absorb the vaporized moisture from the cells or fibres of the lumber.

Many theories have been advanced as to the amount of open space necessary around and between boards in a dry kiln. It is obvious that lumber will dry chiefly through the outside or exposed surfaces, but that face and edge drying will be slower than end drying. This latter must be retarded to prevent too rapid end drying and consequent checking. The problem, therefore, is to secure the right balance between the end, face and edge drying by the use of adequate horizontal and vertical flues in the lumber piles.

Kilns may be *end-pile* or *cross-pile;* i.e., boards may be parallel to or at right angles to the rails. (See Illustration 142.) There seems general agreement that end-pile gives slightly more favorable drying opportunity in the kiln, with less exposure of board ends to circulation of air. However, cross-pile affords larger holding capacity in a given area for the same aggregate capacities in kiln, yard or storage and requires one-quarter less quantities of rails and trucks, with narrower transfer aisles.

The separators between layers or courses of boards on kiln cars are called "lumber" or "stacking sticks." These should be approximately 1-1/2 inch wide, and 1 inch thick, preferably planed to a uniform thickness, so that lumber will be held straight and true during the drying process and not allowed to twist or warp. Sticks should seldom be more than 30 inches apart, and on especially crooked air dried lumber, as gum sometimes appears to be, they should be from 18 inches to 24 inches apart. Sticks should always be in vertical alignment, as shown in the lower portion of Illustration 139 (page 245), and should be bridged or trussed up to prevent sagging or overhanging when they do not come directly above supports.

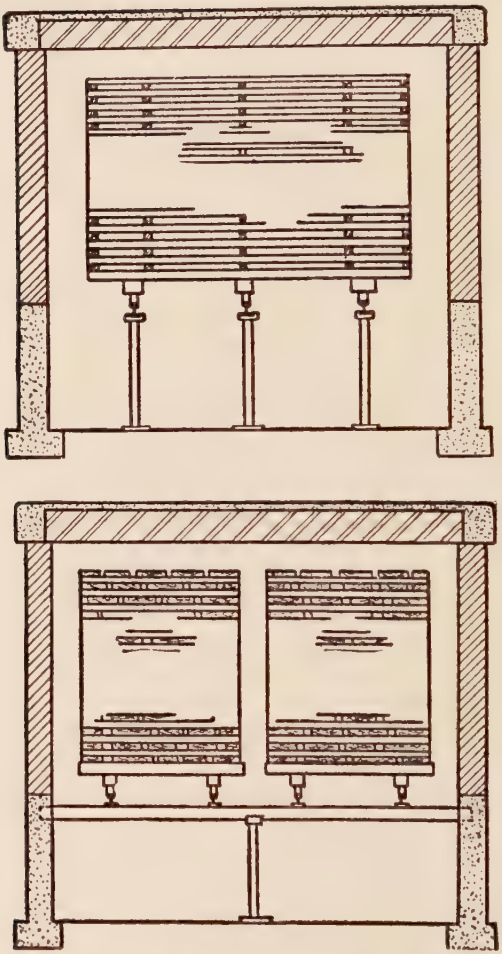

Illustration 142. Showing *end-* and *cross-piled* loads of lumber in dry kiln. End-piled loads allow somewhat better circulation.

Courtesy, *Mechanical Engineering.*

Boards should not be crowded too close together on kiln cars, since approximately one-third of the horizontal area of each course should be open for ventilating space. Chimneys are sometimes provided in piling kiln cars, as shown in Illustration 143. The preliminary steaming process during kiln drying

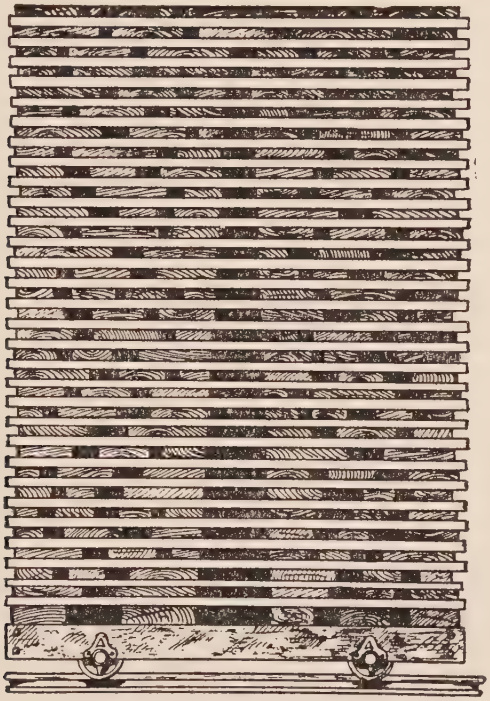

Illustration 143. End view of open-piled kiln car of lumber, permitting adequate ventilation.

Courtesy, *Wood Working Industries.*

will do much to straighten out crooked or warped lumber, but weights should be placed on top of loads to keep the upper courses flat. Kiln loads should not be more than 10 feet high, since higher loads sometimes result in uneven drying.

Schedules and Tests. Dry kilns should be operated on definite schedules, and careful daily records kept of tempera-

ture, humidity and circulation. Carelessness or ignorance are sure to result in slow and irregular drying, with the chances favoring damaged lumber. The testing of atmospheric condi-

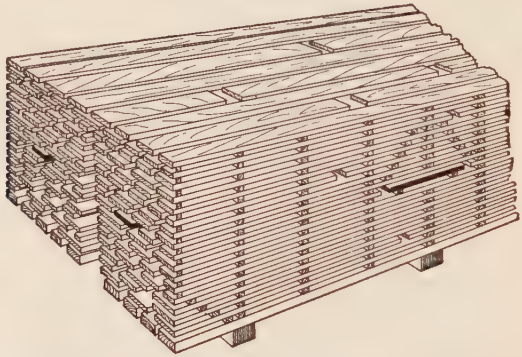

Illustration 144. Showing location of test boards in kiln car of lumber, piled and ready to enter kiln.

Courtesy, *Wood Working Industries.*

tions in the kiln should not be confused with the testing of lumber for moisture content. Loose test boards should be placed in every kiln car when loaded, as shown in Illustration 144.

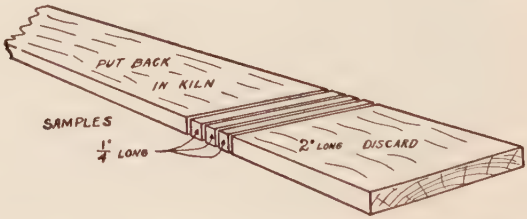


Illustration 145. Showing how samples are sawed from test boards. The odd 2-inch end is always discarded, and the remainder returned to kiln.

Courtesy, *Wood Working Industries.*

These test boards should be sampled before entering kiln and on completion of drying operation. The method of sawing samples is shown in Illustration 145, and the remainder of the test board should be promptly returned to kiln, so that it may continue to be typical of lumber conditions in the kiln.

The method of determining moisture content of samples consists in promptly weighing samples on delicate scales,

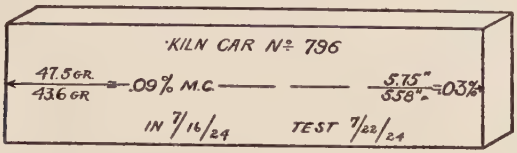


Illustration 146. Showing marking of sample, tested for moisture content (at left) and for shrinkage (at right).

Courtesy, *Wood Working Industries.*

recording weight on sample (see Illustration 146), drying sample without charring, down to a minimum (dry fibre weight) immediately reweighing, recording on sample, and computing as follows:

$$\text{Per cent of moisture content} = \frac{\text{initial weight} - \text{minimum weight}}{\text{minimum weight}} \times 100$$

This result is based on the dry fibre weight as a divisor, as approved by the United States Government. Shrinkage may be similarly tested with a decimal rule, and computed in the same manner, the results being shown on the right in Illustration 146.

Resaw tests for ascertaining case-hardening are suggested in Illustration 147, and for determining uniformity of dryness

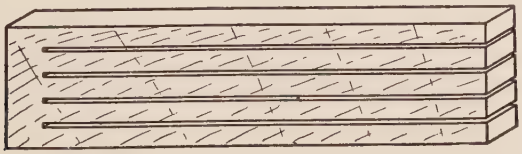

Illustration 147. Showing a resaw test of a sample, which indicates case-hardening if ends of slotted strips pinch together.

Courtesy, *Wood Working Industries.*

between inside and outside of a board, in Illustration 148. Both pieces of outer shell are weighed together before and

after reducing to minimum weight, and compared with the center piece, similarly treated.

When lumber is removed from dry kiln it should be permitted to cool thoroughly or "temper" and should then be kept

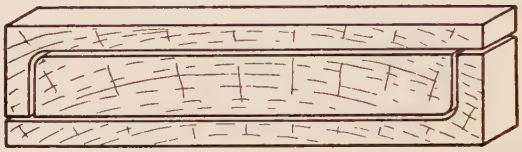

Illustration 148. Showing "shell" test of samples, to determine ratio of dryness between inner center and outer shell of a board.

Courtesy, *Wood Working Industries.*

in warm, dry storage rooms, so that it will be in suitable condition for use when required.

## Dimensioning

In a modern, properly equipped plywood plant, the kiln carload of poplar, or other lumber after being kiln dried, cooled and tempered, is run on to a lumber lift or elevator adjacent to the double surfacer or planer. When lowered on the lift (see Illustrations 149 and 150) the top courses are convenient to the level of the planer table.

From the planer the boards pass to the swing saws or cut-off saws and are successively cut into various assortments of lengths as may be required for use as core lumber. In this operation the sawyer should have a range of available lengths so that each board may be utilized without unnecessary waste. After the major defects are cut from the lumber, the various assorted lengths are taken to the rip-saw where the stock is edged and ripped for the further elimination of defects. From the rip-saw, the dimensioned lumber, unless sawed joints are used, is next taken to the jointers where each board is properly edged or jointed.

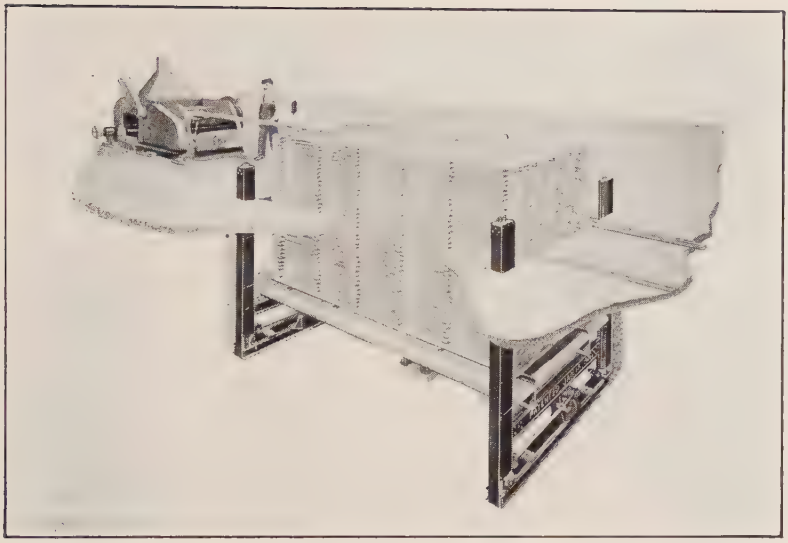

Illustration 149. Showing electrically operated lumber lift, to keep load of lumber at convenient height so that planer operator can work to advantage. This same type of lift frequently used to load lumber from railroad car to kiln car.

Courtesy, Leitelt Iron Works.

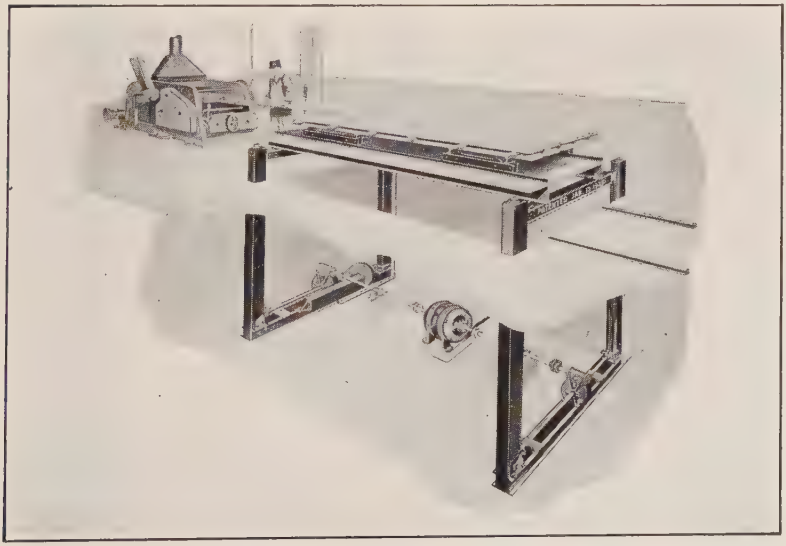

Illustration 150. Showing the same lumber lift at top position with kiln car nearly unloaded.

Courtesy, Leitelt Iron Works.

## Edge Jointing

Edge jointing may be done in two ways, sawed and planed, though preference is usually expressed for an edge joint that is planed before gluing. Jointers are actually narrow planers with high side gauges or feeding chains to keep surfaces and

Illustration 151. Showing at left the straight or flat core joint, in the center the "V" joint (sometimes rounded), and at right the dovetail or Linderman joint.

edges at true right angles. The knives should revolve at high speed and the boards pass over relatively slowly so as to produce true and smooth edges. Joints may be either flat (or square) or "V" shaped (see Illustration 151), the latter type requiring more lumber to provide the "V" which assists in centering the boards on the glue clamp. Square or flat joints are preferred where core edges [1] (after assembly into plywood) are to be moulded or otherwise made conspicuous. It is doubtful whether the "V" joint is economy in the long run.

Sawed joints are produced on especially designed rip-saws which give unusually smooth, straight saw-cuts. The minor irregularities may give lodgement to the glue and the joint be pressed together so that it is difficult to distinguish it from the planed joint. Obviously, a well-made sawed joint can be produced more cheaply than a planed joint, and by some is regarded as entirely satisfactory, especially in work where prices are highly competitive and costs must be closely guarded.

The sections or boards of each core are now laid together flatwise ready for matching.

[1] See also Illustration 173, page 301.

## Matching Saw

From the jointer, the pieces which have been cut to length and ripped to width, with all major defects cut out, are taken to the matching saw. At the matching saw, the guides are set to the exact widths necessary for making glued up cores, and a sufficient number of pieces are placed on the matching table, with a wide board on the outer edge so that in ripping to exact width there is left a board two or more inches wide. This board, in turn, is laid on the matching table and is used on the outer edge of the next series of pieces to be used in cores which may be designated, until the required number of cores on any specific order is assembled.

Following the matching, the boards of each core are laid out in layers on a truck, and roughly marked with chalk to facilitate reassembling on the glue clamp.

## Glue Clamps

From this operation the stock is taken to the glue clamps, where the edge of each separate piece is covered with glue, placed in clamps and pressure applied. The glue may be applied by means of a small roller, over which the edges of boards are passed, or by means of a platen type glue spreader, in which the perforated or corrugated platen can be raised out of the glue on which the edges to be glued are rubbed. The former type of edge glue-machine is shown in Illustration 152.

After edge gluing, the adjacent boards are either held together in hand clamps and piled in layers on a truck, or are clamped together in revolving clamping machines. Such a device, consisting of many individual leaves, is shown in Illustration 153. Each layer has side clamps and may have end and top clamps or guards as well. With a quick setting animal, vegetable or casein glue, the cores should not be removed from the clamps in less than one hour. Some manufacturers place

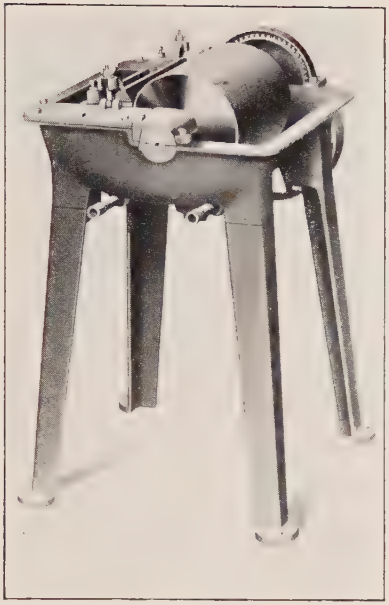

Illustration 152. Glue roller, in steam-heated bath, used to apply glue to edges of lumber or veneer.

Courtesy, Chas. E. Francis & Co.

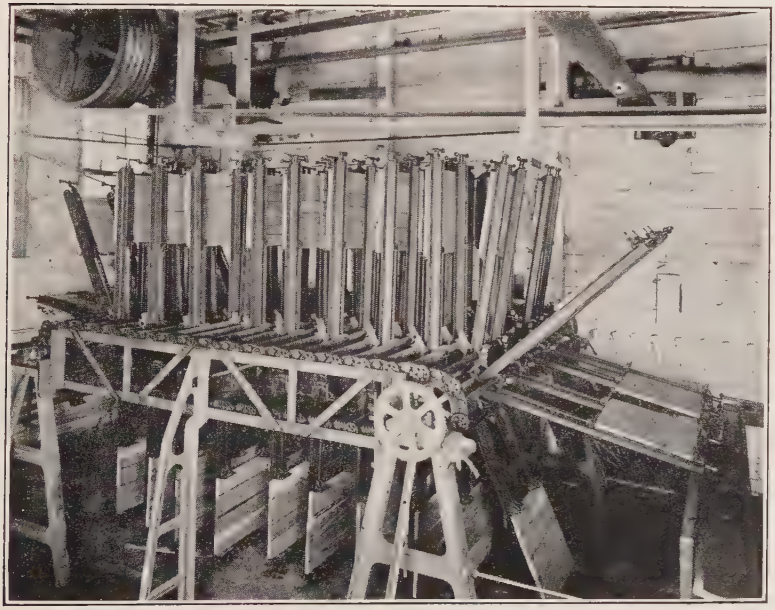

Illustration 153. Revolving clamp, used for glued lumber core stock.

Courtesy, Taylor Manufacturing Co. and Grand Rapids Veneer Works

boards in a warming oven or on a hot table before gluing, to aid in setting the glue, but it is doubtful if this is necessary except in cold weather or when gluing is done in a room with a temperature under 75° F.

Another method of jointing and gluing cores is the dovetail glue jointer, in which there is combined, cutterheads for dovetail edge jointing, a roller glue spreader, and an automatic feed to force the boards with dovetail tongues into the grooved boards. Only one type of machine has been available, and its cost and intricacy, together with the lumber wasted in making the tongue, has limited its more general adoption by the trade. The type of joint produced is shown in Illustration 151. This combination machine usually is equipped with a rip-saw, to reduce each random width core to the proper size, and to permit the utilization of the remainder in the next core.

In removing the glued up cores from the clamps, it is considered good practice to place them on trucks with sticks between each core, and then put them in dry kilns, where they remain until all the glue moisture is dried out from the joints. Otherwise sunken joints will be apparent, as is later mentioned and described.

## Surfacing

An indispensable operation, after removing cores from clamps, and before final surfacing, is to allow the glue joints to dry out thoroughly before surfacing. The application of glue to the edges naturally introduces some water into the wood and swells the wood somewhat at the joint. If surfaced before this glue moisture has been dried out of each joint, the subsequent drying after surfacing will produce small depressions, or "sewers," in the core, which are likely to be apparent through the face veneer of the finished plywood. If unsurfaced cores are piled up with sticks or slats between, and allowed to season for five to seven days under ordinary workroom conditions,

they can be satisfactorily surfaced to final thickness. If redrying kilns are available, one or two days in such a kiln should be sufficient.

Toothing, or roughing, the surfaces of a core to make the glue stick better, was formerly quite customary, but has fallen into disuse in recent years. It seems to have little, if any, real merit.

## Railing or Banding Cores

A core made by the above method is said to have "raw" edges, and the end of a table top will show end grain lumber

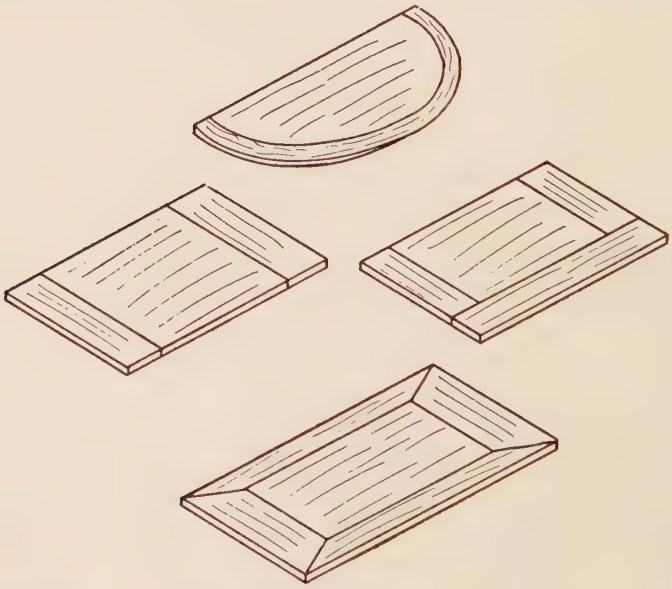

Illustration 154. Showing different kinds of banding on cores; at top, rim bound for circular tops; at left, banded two ends; at right, banded two ends and one side; and at bottom, banded four sides with mitered corners. Other combinations of banding are also used.

that sometimes finishes much darker than the exposed side grain.

In order to avoid the exposure of end grain and to permit better edge finishing, cores are banded or railed, usually with a wood similar to or which will take a finish similar to that of

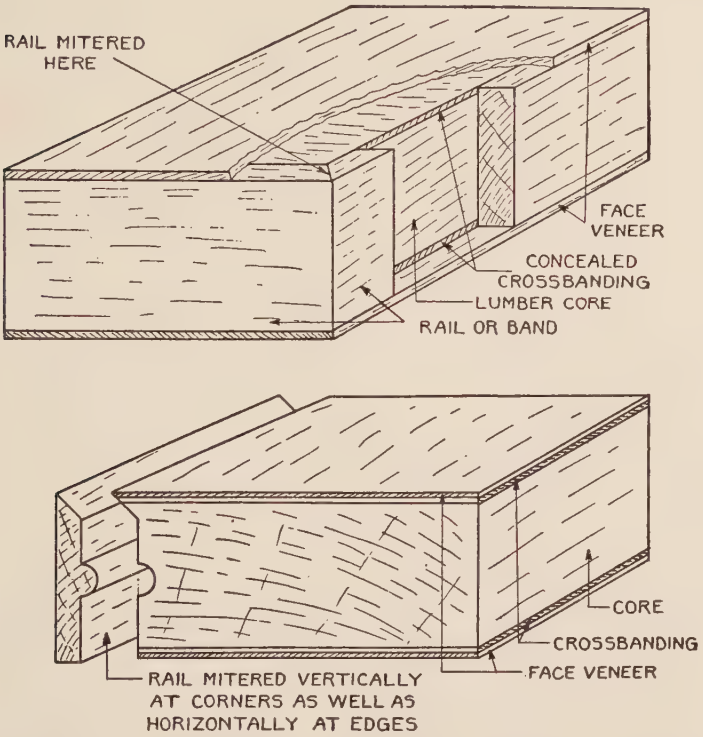


Illustration 155. Showing above "concealed crossing" construction for desk beds, mitered band of same wood as face veneer is cut away to show lumber core; below is another construction in which banding is mitered at both edges and corners. This conceals edges and ends of face veneer, as well as of crossings.

the face veneer. Illustration 154 shows several varieties of core banding, the simplest thing is the *straight end* banding at the left, and the most difficult is the *mitered* banding at the lower center, used where joints or the showing of end wood would impair appearances. The *rim-bound* top shown above was used chiefly for circular extension dining-tables which

were in vogue for many years, but which now are seldom manufactured. The combination *side and end* band shown at the right is made in many varieties, with either band overlapping as conditions require.

Edge banding is usually done with a flat joint and end banding with a tongue and groove joint just after cores are re-

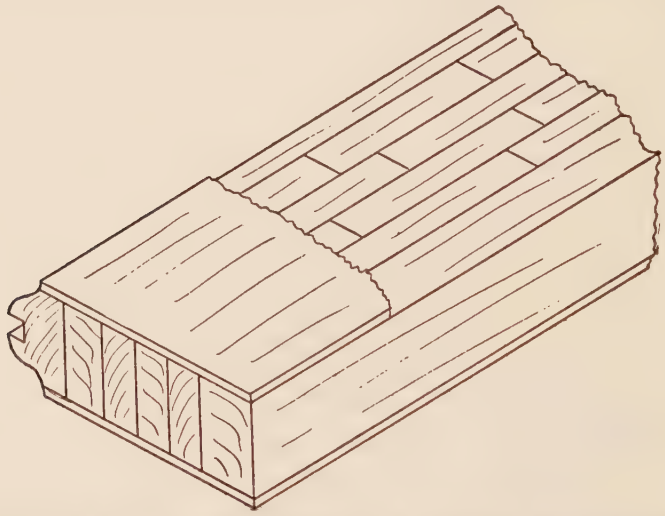

Illustration 156. Showing construction of door stile, with 1/8-inch face veneer, laid with the grain parallel to segmental core, core being railed with the same wood as face veneer.

moved from glue clamps, and before final redrying and surfacing. Core ends must be trimmed square, bands or rails usually being about three or more inches wide. After banding, cores are surfaced in the usual way.

Another type of banding is used in the making of plywood to be used for desk writing beds. These are usually 1–1/4 to 2 inches thick and square edged. The end of a desk top should not show the cross-band, which may be 1/12 inch or 1/8 inch thick, and this is accomplished in the types of construction shown in Illustration 155, which are usually termed *concealed crossings*. In such cases, the core and crossings are built up

into 3-ply, then banded on four sides with end-mitered bands 1/4 inch thick, of the same wood as the face veneer. The banded 3-ply core is then planed true and the face and back veneer glued in place. This construction is more durable than the usual veneered edge construction.

Door stiles and rails are usually made with a grain of all plies in the same direction, the core being banded on both edges with the same wood as the face veneer, as shown in Illustration 156. Cores are usually made up of narrow, short strips, which are virtually offal from other operations. Rails are made up in the same way.

## Repairing Cores

It is inevitable that some cores should fail to be perfect when finished. At the prevailing prices of lumber, it is an unjustifiable economic waste either to cut such imperfect cores into smaller sizes or to destroy them, where repairs can be effectively made.

*Round wooden plugs* of various diameters up to 3 inches, are frequently used to replace loose or shaky knots which have been bored out. Wedges or "dutchmen" of various shapes and sizes can be used for more irregular defects. It is customary to have a supply of various shapes—marking around the selected plug, band-sawing just inside the mark and gluing the plugs in place. Plugs should rarely if ever be placed on exposed edges where they will show. Boring machines with "male and female" hollow bits are used by some plywood manufacturers in making repairs in defective cores.

Low spots or places torn out by planer or saws are sometimes filled with a *composition* of plaster of Paris and sawdust, but such repairs are less desirable, and should seldom, if ever, be used for the face side of finished plywood.

Any repaired spots should be scraped down flush with final core surface—so that unevenness will not show through veneer.

Well-made repairs in 5-ply work should not be censured, but in 3-ply work they will inevitably show through the face veneer when finished. In other words, the cores for 3-ply must be better than those for 5-ply, since the crossings usually prevent repairs from giving evidence of their presence.

When cores are "ready to lay" they should be stored in a warm, dry room until, with the crossings, faces and back veneers, they are ready to be glued into finished plywood.

# CHAPTER XXV

## GLUES USED IN THE MANUFACTURE OF PLYWOOD

### Descriptive Data

The employment of an adhesive between pieces of wood is undoubtedly very ancient. It is known to date back into the age of regal splendor of ancient Egypt, as the sculptures of Thebes disclose the use of glue, heated in a pot over the fire, and applied to pieces of wood with a brush. The probable date of this graphic delineation of the early methods of gluing is some 3,500 years ago, supposed to be during the reign of the Pharaoh of the Exodus. (See Illustration 1, page 5.)

We know that much of the wooden furniture discovered in the tomb of King Tutankhamen gives indisputable evidence of the use of glue, both in veneering and in joint work. As to the character and the ingredients of this early glue, we know practically nothing, although the fact that it was melted over a fire, spread with a brush and the glued pieces laid together, and held down by means of stone cauls weighted down with bags of sand, leads us to suppose it was similar to the animal and fish glues of the present time.

There is also evidence to show that casein glue was known to the ancients, as indicated in the following quotations:

> The ancient Egyptians already employed the art of ennobling an ordinary wood by gluing on thin layers of costly woods.
>
> For example, the corner posts of a large mummy case now in the Berlin Museum are overlaid with a veneer almost one centimeter thick.
>
> Glue was a favorite fastener. There were two kinds of

glue, the common kind, joiner's glue made from animal offal and fish bladders—and also the glue made from caustic lime and white of egg or casein, which had already been discovered by the Egyptians.

Their wish to construct rich furniture at lower cost, as well as the experience that the use of a suitable core-wood makes flat pieces warp less than when heavy boards of costly wood were used, led them to adopt ply-work. This was cut with saws and fastened to an under layer of other wood with glue. Thus they made table tops, chests, beds, etc.[1]

Not only are there references to the use of glue by the Egyptians and the Greeks, but also to the use of adhesives by the Romans. As described by Pliny:

Glue, too, plays one of the principal parts in all veneering and works of marquetry. For this purpose the workmen usually employ wood with a threaded vein, to which they give the name of "ferulea," from its resemblance to the grain of the giant fennel, this part of the wood being preferred from its being dotted and wavy.[2]

There is little to show that adhesives were used in Europe through the Middle Ages, although it is probable that animal glue was well known and commonly used. Casein was also a recognized adhesive, although its use was undoubtedly more rare.

No records have been found to indicate the use of other than animal glue in the early American colonies, and in the United States up to the latter decades of the 19th Century.

## Kinds of Glue

Modern methods and the needs of the modern plywood industry have brought about the development of several acceptable adhesives, each of which has certain well-known characteristics.

[1] "The Story of Furniture," translated from "Geschichte des Mobels," by A. Koeppen and C. Breuer. Published at Berlin, 1904, pp. 56–7, 121–2.

[2] Pliny's Natural History, Book XVI, Chap. 83, Bohn's translation.

The principal classes of glue now in use may be listed as follows:

Vegetable glue
Animal glue
Casein glue
Blood albumin
Sodium silicate (water-glass)
"Liquid" glues

Each of these will be discussed in the following pages.

## Theory of Gluing Wood

The actual process by which glue acts to bind together two pieces of wood has been the subject of much discussion, but it seems that the following theory roughly explains the mechanics of the action of the various glues, and that it will be worth while to consider it.

The first essential property of a glue is that it shall be fluid enough to be spread evenly on the surface of the wood, and having been spread, to remain sufficiently fluid to send out tiny fingers or prongs into the spaces between the fibres of the wood. This constitutes the first step of the process in the making of the joint.

The second essential property of a glue is that, having penetrated into the open spaces or pores between the fibres of the wood, it shall then be of such a nature as to become jellified, or, in other words, change from a liquid to a semi-solid which now does not penetrate further or pass through the cell walls of the wood but remains in the joint in an exceedingly thin irregular film having tiny fingers extending into each of the pieces of wood on either side. This constitutes the second step. The processes attending the accomplishment of the second step vary with the different glues.

The third essential property of a glue is that it shall be capable of drying and of drying into a body having strength.

This last named property also constitutes the third step, which is the actual drying of this film of glue and all of its fingers or prongs so that it becomes an actual solid, having mechanical strength sufficient to retain its shape and to hold unbroken each of its many fingers. These fingers, in turn, act as so many tiny nails extendings into the fibres of the wood of each glued surface and make one unit of the various surfaces glued. (See Illustration 157.)

Vegetable glue, for example, is a very thick fluid, and is forced, by the applied pressure, in between the fibres of the wood, and the wood, being dry, immediately begins to absorb the water from the glue (water, being noncolloidal and having small sized molecules, can pass through the cell walls). Thus vegetable glue becomes jellified or "set" through simple subtraction of water.

This subtraction of water applies to all other glues as well as to vegetable glue, and is also the unassisted cause of the setting of so-called "liquid" glues.

In the case of animal glue, the subtraction process is assisted by the "jelling" of the glue, due to cooling. The animal glue is kept liquid by heat and is applied to wood which is at a slightly lower temperature than the glue itself, so that after penetrating to some extent into the fibres of the wood, it cools, "jells" (becomes semi-solid) and finally dries or "sets." If the wood is too hot, this jelling is interfered with, and the glue penetrates so far that it is more or less dissipated and a mediocre or weak joint results. If the wood is too cold, the first step of penetration is prevented because the glue jells or solidifies immediately on touching the cold wood and cannot penetrate in this case no joint results.

Some casein glues have a still different way of assisting the subtraction process. Chemical reactions are started in the glue as soon as it is dissolved, which, proceeding rather slowly, leave the glue fluid long enough to be spread and to accomplish the necessary penetration, but which reactions in a few hours pro-

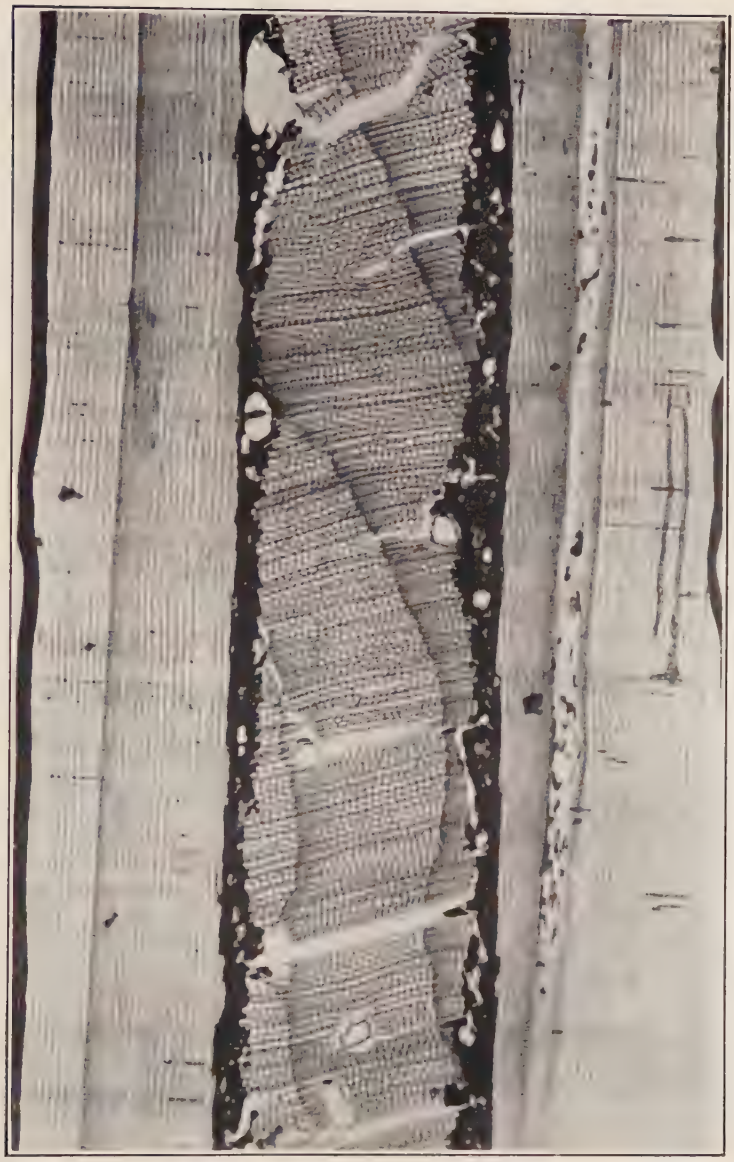

Illustration 157. Showing a magnified cross-section of a glue film, cut across a piece of 3-ply, the darker portions indicating how glues penetrate the fibre of the wood. The wood is soft pine, glued with blood albumin glue.

Courtesy, Eloise Gerry in *Scientific American.*

ceed to completion and cause the glue to jell of itself and become quite tough and rubbery. With these glues this would occur, whether the glue was spread or not, but occurring on the joint, it produces the adhesion.

A little thought along the lines indicated shows why glues are necessary colloids and why some substances are glues while others are not. Molasses, for instance, is not a glue for the reason that sugar has small molecular size and would pass through the cell walls of the wood and be dissipated. Further, it does not and cannot jell nor become semi-solid. Lastly, even if dried, it has little mechanical strength.

Further consideration and understanding of these facts will point the way to further advances in the use and testing of present glues and toward the development of new ones.

## Vegetable Glues

Vegetable glue is essentially a mixture of starch dissolved (or more accurately, peptized) in a solution of caustic alkali.

Its use first became important in plywood making in the United States about 1910. One of the earliest records of its production is in an old German formula book dated approximately 1870, which gives directions for preparing "apparatine" from starch, water and caustic soda.

Vegetable glue as used in woodworking, has practically nothing in common with the familiar household pastes and mucilages which are also made from starches.

Its appearance in prepared solution in the plywood factory is as a transparent amber colored liquid of such character that the observer is in some doubt as to whether it is a semi-solid liquid or a semi-liquid solid.

Dry vegetable glues, as has been stated, consist chiefly of starches, the usual predominant starch being tapioca, which is produced mainly in Java. It comes to the plywood glue room as a white powder or as easily crushed granules packed in

glue should be under five per cent although experimentally in laboratory tests, veneers containing ten per cent water will frequently show good glue joints.

Vegetable glues, after being cooked, have a long working life, i.e., can be kept over from day to day in the spreader or

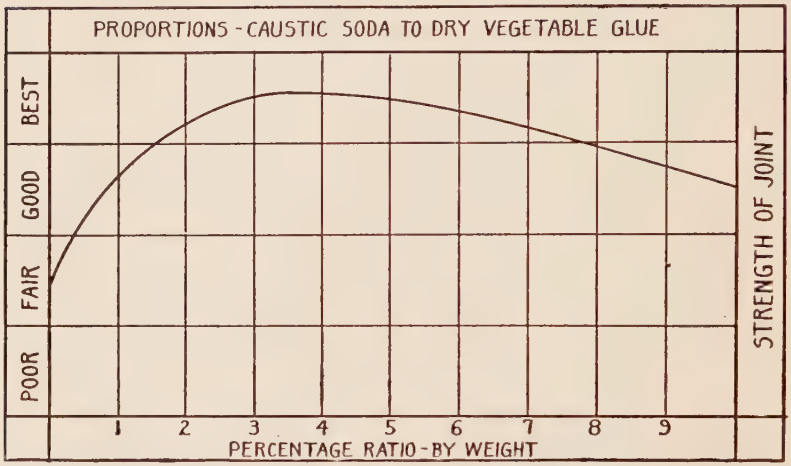


Illustration 158. Showing relative strength of joint made by using mixture of vegetable glue and caustic soda.

Courtesy, Glover M. Birk.

mixer, and used a week after mixing, without serious sacrifice of strength, although it is considered advisable not to carry over remainders for more than two or three days.

Vegetable glue is not waterproof. It is, however, proof against dry bacterial decay and against the influence of dry heat.

## Animal Glues

The ordinary animal glues of commerce are by-products of the meat packing as well as the hide and leather industries. Almost anything that cannot be developed into edible or wearable form is converted into some grade of glue or fertilizer. The process of the making of animal glue can be found fully

described in two books, written by Robert H. Bogue and Jerome Alexander.[3] Gelatine, in its table form, is the highest grade of animal glue, made almost entirely from hide materials.

The commercial grades of animal glue are many and are variously described by different manufacturers, but are not as yet reduced to any generally accepted standards. The purer grades of hide glue are the best, where strength is required, and the gradation is downward into the lower grades where their utility is chiefly as fillers and joint tighteners, rather than as true adhesives.

Animal glues are easily prepared for use by dissolving in water, and keeping the solution at the desired degree of fluidity by heating in a double-boiler or similar receptacle. Cookers for animal glue, arranged for heating either by means of steam or electricity, are on the market in many forms. The temperatures for animal glue should ordinarily be 140° to 150° F. Higher temperatures tend to reduce the strength and lower temperatures favor bacterial decomposition, as well as cause the glue to become too thick to spread properly. High grade glues work well with two parts of water to one part of dry glue (by weight), and may under careful use be reduced to three parts of water. The lower the grade of glue the weaker the joint, no matter what ratio of water is used.

Animal glue has excellent penetrating qualities, if applied to wood at the proper temperature, but requires heat in its preparation for use, must be kept hot, and (when large surfaces are to be glued, as in plywood) must be applied in an overheated room to wood or veneers which are often preheated. When used by means of a mechanical spreader, the machine must be kept sufficiently warm to avoid chilling the glue.

Due to its qualities of thickening rapidly, as it cools, and to its deep penetration into wood, the surfaces covered with

[3] "The Chemistry and Technology of Gelatine and Glue," by Robert H. Bogue. (Mellon Institute Technochemical Series.) Published by McGraw Hill Book Company, New York, 1922.
"Glue and Gelatine," by Jerome Alexander. (American Chemical Society Monograph Series.) Published by the Chemical Catalog Company, New York, 1923.

glue must be brought together under pressure as soon as possible, within five minutes if spread glue is fully exposed to the air, and within ten minutes if partially exposed.

In present-day plywood production, animal glue is used chiefly for gluing the joints of lumber cores, the joints of face veneers, for veneering the edges of table tops, and for other special work of similar character.

No great success has attended efforts to make animal glue waterproof. Neither is it heatproof, i.e., dry heat may cause animal glue joints to fail.

Animal glue is, nevertheless, an exceedingly useful adhesive. It adheres quickly, sets quickly and joints may be made perfectly tight, practically without pressure, if the surfaces to be glued are spread with animal glue, placed in contact and rubbed together a few seconds. It is easily applied with a brush and is strong far beyond the usual demands made upon it.

## Casein Glues

Casein was known as an adhesive in ancient Egypt and medieval Europe, but apparently did not gain recognition in the United States until about 1870, and then in the bookbinding trade and as a coating in paper manufacturing. But its moisture resistant qualities as a wood glue were relatively unrecognized in this country until some ten years ago, when airplane construction demanded a wood adhesive more waterproof than either animal or vegetable glue.

Casein is the albuminoid constituent of milk. It is produced commercially either by allowing skim milk to sour or by adding acid to it. The casein is precipitated in the familiar form of curds. It is then separated from the whey, washed, dried and ground usually to 30 or 40 mesh fineness.

Argentina is the principal source of casein. There the annual production is from twenty-five to thirty million pounds,

while this country turns out five to ten million pounds in the same period, the states of California, Wisconsin and New York heading the list.

Casein glues in general are quite resistant to moisture or water, and even to boiling water, which is their chief advantage in plywood construction. None of them are strictly waterproof in the same sense that, for example, rubber is waterproof.

Casein, itself, as it is known in commerce is a hard, horn-like, gritty powder which swells when placed in water but does not dissolve. Chemically, and for glue making purposes, it acts as a weak acid of colloidal nature, being somewhat analogous chemically to the fatty acids in soap.

It can be made to dissolve in water by adding an alkali as caustic soda, soda ash or borax; this will yield a strong glue if the alkali is added in amount insufficient to complete its conversion to sodium caseinate, but still sufficient to convert a part of it to caseinate, which portion peptizes the uncombined portion of it into a thick colloidal solution having the properties of a fairly good glue. Such a glue is not at all waterproof, but, as might be expected, after drying, will readily redissolve in water.

Hydrated lime, if added to casein and water, acts upon casein toward the formation of the insoluble calcium caseinate. This, too, may be used as a glue, and of course is waterproof, though rather brittle and having little tackiness and low penetrating properties. In order to use a mixture of casein, lime and water as a glue, it must be applied under pressure while the reaction is in process and before its completion.

The casein glues actually used in the plywood industries are combinations in various degrees between the two types explained above. That is, they all contain an alkali which acts to partly peptize the casein as sodium caseinate, giving the glue strength, penetration, working life and elasticity; they also contain lime, which progressively acts on the uncombined casein and on the sodium caseinate to form the insoluble calcium

ations for glue, must be carried on at temperatures well below 160° F., the coagulation point of albumin. Only when the glue is spread and the veneers inserted in the press, is it desirable to exceed 160°, and then it is for the specific purpose of coagulation, which hardens the glue and makes a practically waterproof glue joint.

There are several patented processes for making this glue, but one of the best known is the following:

100 pounds black soluble blood albumin (90% soluble)
180 pounds water at about 80°F.
4 pounds ammonium hydroxide (Sp. Gy. 90)
3 pounds hydrated lime

The blood albumin is allowed to soak in water for a couple of hours, and should then be stirred slowly, and strained if necessary to remove insoluble particles. The ammonia is then added, while it is still stirred sparingly to avoid a foamy glue. Lime is finally added in the form of a thick cream and gentle agitation continued. Care should be exercised to avoid an excess of lime, which may thicken the mixture unduly until it approaches a jelly. The final glue should be of a moderate consistency, and will remain suitable for use for several hours. This glue may be mixed and applied at normal room temperatures without artificial heat or cooking. It may be applied with either brush or mechanical spreader, but the spreader rolls must not be operated except during spreading, since idling them in the glue has a tendency to develop foam.

To secure the full advantage of coagulating the glue by heat, the veneers should be as thin as possible, preferably not over 1/16 inch thick, and no glue strata should be more than one thickness of veneer away from the hot plates. Multiple plies must be glued singly on each side of previous product, and thus each layer of veneer properly "set."

It is customary to place single 3-ply panels with freshly glued surfaces into the press separately, or to have a press equipped with heated platens in vertical tiers, in which a panel

can be placed between each pair of platens. The temperature of the press may go as high as 212°, so that an elapsed time of three to five minutes may produce temperatures exceeding 160° at the glue strata under pressure. No time should be lost between spreading glue and getting the freshly glued material under hot pressure. Upon removal from the press, the joint should be as waterproof as it is possible for a joint to be between veneers and wood that are not waterproof.

Blood albumin glues, when spread on veneers and veneers assembled together (before glue is coagulated by heat) can be soaked in water until the veneers are sufficiently pliable to be bent into special forms. The plastic plywood is then pressed into desired shape in hollow, heated press platens, and the temperature raised to over 160°, producing when dry, waterproof curved plywood shapes. This procedure has a wide application in engineering uses, and its utility has hardly been appreciated as yet.

A process of rolling or pressing dry blood albumin glue into thin sheets of glue was developed during war time.[4] Such glue sheets could be placed between layers of wet veneer and pressed in a hot press, and the resulting coagulation would be nearly as satisfactory as the use of wet glue on dry veneers. This sheet glue process is most suitable for very thin veneers, 1/40 to 1/100 inch where any fluid glue would penetrate and stain the surface of plywood seriously. The process is, however, rather complicated for ordinary use.

A different blood albumin mixture has been developed, experimentally, that is claimed to be waterproof when applied and allowed to set cold. The process is too new and untried to warrant drawing conclusions regarding its effectiveness. If, however, waterproof qualities can be obtained in ordinary plywood procedure, with blood albumin glues, producing full retainers, containing bundles of glued stock two feet thick, it opens the way for many broadening adoptions of plywood.

[4] See Report No. 66, "Glues used in Airplane Parts," Forest Products Laboratory, Madison, Wisconsin, 1920.

Blood albumin is a somewhat disagreeable material to work with, but is not as brittle as casein, has approximately the penetration of animal glue, and is as simple to use as the other glues described, except for the requirement of hot pressing.

### Sodium Silicate

Sodium silicate is produced solely from mineral materials by fusing together sand and soda ash. The resulting product is dissolved in hot water and is the familiar "water-glass." There are many modifications of water-glass, depending on the molecular ratio of soda to the silicate group and upon the content of water. The silicate of soda used in woodworking, however, is a clear syrupy liquid. It is never used for plywood work in furniture, but only in making plywood for box shooks. Joints made with water-glass fail of themselves after a few months because of the slow action of the air on the alkali of the silicate, and the general breaking down of the colloid. It is a very cheap and excellent glue for its particular purpose, as it is waterproof and produces plywood for tighter, stronger and lighter packing cases than could be made from solid wood.

### Liquid Glues

These are largely prepared glues and seldom used for extensive factory production work, because of cost. By far the larger proportion are made from fish bladders and the best grades have excellent strength qualities. These glues are chiefly used in repair shops, for household requirements, and for factory purposes where limited qualities are required, such as dowel setting, and the application of overlays, as well as ornaments and the like. For operations where continuous heat is not obtainable, they may prove useful in factory work, though not so satisfactory as animal glue, or casein joint glues.

Probably the general public unconsciously thinks of liquid

glues, whenever glue is mentioned, but such preparations are in no way typical of manufacturing materials or procedures.

## Glue Testing

The scientific testing of glues presents an unusual combination, having both organic and inorganic elements, and being a combination of the sciences of physics and chemistry. As early as 1844, Peter Cooper laid aside a graded set of animal glues, but he was a glue manufacturer and his comparative tests could not be entirely freed from that association, and yet in spite of this fact, his standards are still the recognized measures of glue quality.

The National Association of Glue Manufacturers is earnestly attacking this problem of better standards of quality, of measures of adhesiveness and of purchasing specifications. Their interest, however, lies largely in the direction of the animal glues, and little, if any, in the field of other adhesives.

Certain tests, however, are known on all types of glue, and no glue of any kind should be used until the available tests have been made on typical samples and the adhesive quality approved.

Here is a fertile sphere for industrial research in a relatively undeveloped field—research that would clarify and improve the practice and manipulation of a familiar product in an obscure though ancient branch of industry.

## Comparison of Glues

Each kind of glue has its advantages and its ardent advocates, but it may reasonably be said that no glue is superior to all others in all respects.

Vegetable glues are lower in price than animal glues and have been generally adopted by the veneer and plywood trade because of their strength and excellent working qualities and

because their uniformity of strength and of spread is easily superior to that of all other glues (except perhaps casein) for plywood purposes. When properly mixed and applied, they are stronger than wood, and tests will more often show wood than glue failure. They are not water resistant to any appreciable extent and cannot be applied with a brush.

Animal glues are known everywhere, and the best grades are considerably more costly than others except fish glues, but they are universally recognized as excellent adhesives for certain purposes. They are not water resistant, and will not hold wood together in moist or damp or hot, dry locations.

Casein and blood albumin glues have highly water resistant qualities, in fact, either may be made practically waterproof. They are between animal and vegetable glues in cost. The cement-like qualities of casein, and the heat coagulation requirements of blood albumin make their use somewhat more difficult than either animal or vegetable varieties. The water resistant qualities, however, are most desirable in the building of doors, for exterior openings, automobile and bus bodies, and other exposed surfaces. The hot press equipment required in blood albumin glues adds materially to its cost of application.

## Glue Mixers and Converters

Animal glue can be dissolved and melted down in almost any kind of double-boiler, where only small quantities are desired, and it is not necessary to keep it continuously in prime condition for economical spread and maximum strength. Other glues, however, require mechanical mixers, as does animal glue when used in large quantities.

Vegetable Glue Converters. Since this glue is used chiefly for veneering purposes, although some is used for edge gluing, and that in relatively large quantities, these machines are made in from 50 to 150 gallon capacities. During certain

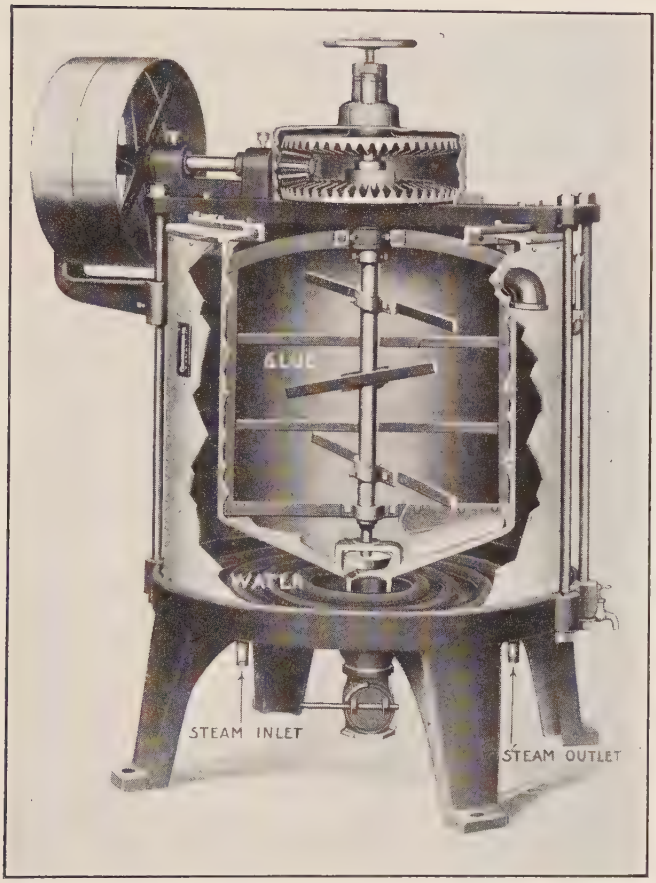


Illustration 159. Showing water-jacketed, steam-heated, mechanical mixer, suitable for either vegetable or casein glue. May be driven by belt as shown or by direct connected electric motor.

Courtesy, Chas. E. Francis & Co.

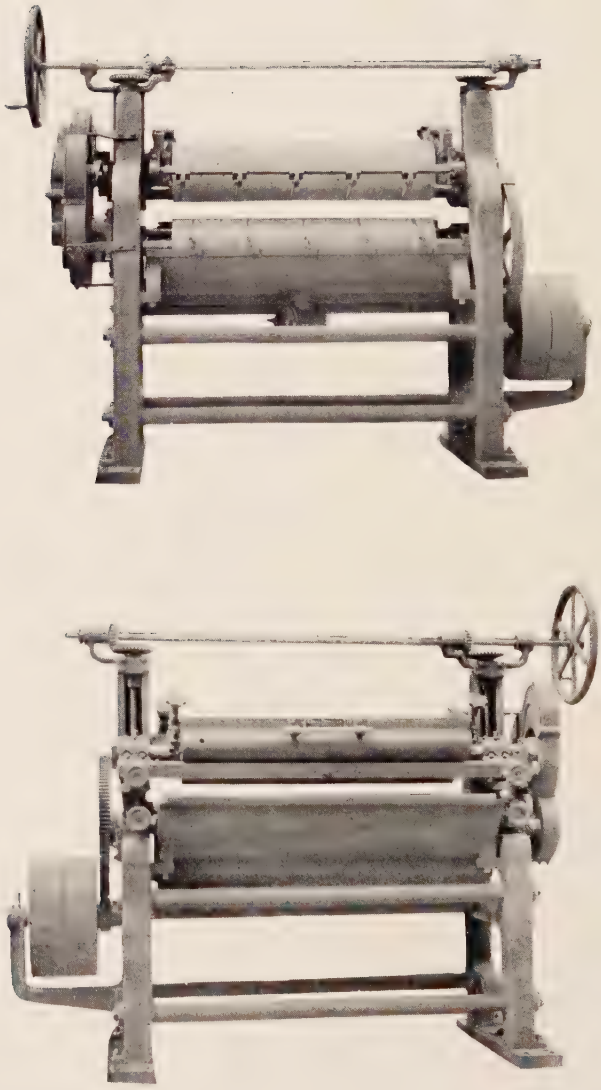

Illustration 160. Showing above the delivery side of a glue spreader and below the side into which the dry unglued veneer is placed.

Courtesy, Chas. E. Francis & Co.

stages of conversion, the glue is thick and viscous, so that sturdy mechanical agitators are required. These are arranged to scrape the inside of the kettle and thoroughly mix its contents. (See Illustration 159.) Considerable power is required to revolve these beaters at from 50 to 60 revolutions per minute. The outer jacket should be equipped with steam connection, as well as with water supply (for rapid cooling) and drain to sewer. A thermometer should be attached, showing actual temperature of glue during mixing. These glue converters are often located in galleries or balconies over the spreaders, frequently on the floor above, with adequate discharge pipes to convey glue to spreader as required. Convenient arrangements should be made for handling heavy bags of glue and for weighing powder and liquid ingredients.

Animal Glue Mixers. These are usually of the heated jacket type, operated by steam, gas, oil or electricity, and require a single revolving heater or agitator. The open top of the kettle should be covered to prevent evaporation and filming over. Thermometers should be provided showing temperatures of glue (not jacket), which should never exceed 140°. Beater speed need not exceed 25 to 30 revolutions per minute but should be continuous.

Casein Glue Mixers. These are quite similar to the converters used for vegetable glue, but should be connected up for 100 to 110 revolutions per minute, since casein requires more vigorous stirring, for a short period, than any other kind of glue. The outer heating jacket is not required for casein, but the mechanical aids to weighing and measuring are necessary. These mixers are also placed above the spreaders so that glue will flow by gravity from mixer to spreader.

Many plywood factories equip their mixers with variable speed connections, to accommodate either casein or vegetable glues, and to supply the complete cooking connections used with vegetable glue, as most plywood makers find it convenient to

use different glues for varying requirements. The revolving beaters in the casein and vegetable mixers resemble the double beaters placed in household ice-cream freezers. The mixers should not have parts made of brass, copper, or aluminum.

Blood Albumin Glue Mixers. This kind of glue is best mixed by mild, gentle stirring or agitation that is not sufficiently active to cause foaming. Hence, kettles which can be given a twisting or rocking motion are preferred. This type of glue is mixed cold and does not require mechanical heaters.

It is important to observe accurate measurements in mixing all of these wood glues. The reactions of chemicals and heat are sometimes quite unexpected, but close adherence to makers' instructions and actual experience, will soon reduce the apparently complicated procedure to simple and familiar form.

It is never safe to use a batch of glue, concerning which there is any doubt as to quality or strength. A few hundred square feet of defective plywood is much more costly than the loss of a batch of glue of uncertain adhesive strength.

## Glue Spreaders

Several of the glues described can be spread by means of a brush, but in veneer work this hand method does not satisfactorily spread glue over large surfaces evenly and quickly. Mechanical spreaders, shown in Illustration 160, have corrugated rollers, with adjacent glue reservoirs, in which sufficient glue can be kept, to maintain continuously an even layer of glue over each roller. The supply of glue is controlled by means of adjustable pressure bars or rollers, and the delivering rollers can be spaced apart for varying veneer thicknesses. Pointed metal fingers are used to deliver glue covered sheets of veneer and to keep them from following around the spreader roll. In the case of animal glues, the temperature in the reservoirs for supplying glue to rollers, must be kept at approximately 140°.

The glue spreading rollers are gear or chain driven, and should be provided with corrugations lengthwise, so that glue can be properly retained until deposited on veneer.

As to the corrugations, their shape, size and depth, there is considerable variation in practice. Certain spreaders operating on vegetable glue, and known to be giving excellent results, are equipped with corrugations 1/24 inch wide, twelve to the inch, and about 1/32 inch deep.

Another spreader, which is spreading casein glue satisfactorily, has corrugations 1/16 inch wide, eight to the inch, and about 3/64 inch deep.

Animal glue is best spread with about four corrugations per inch and about 1/20 inch deep. These corrugations are sometimes made with square, rounding or tapering sides.

Operators on spreaders using caustic glues should be equipped with protective gloves.

Glue spreaders should be frequently cleaned with a steam hose, that fresh glue supply may be free from hardened particles of glue, and may be of the proper consistency.

# CHAPTER XXVI

## GLUING VENEERS UNDER PRESSURE

### Historical Methods

Rarely has history given us such a graphic and understandable glimpse of ancient craftsmanship, as is found in the historic city of Thebes. In those early days the journeyman carpenter must have possessed great versatility, as he not only built the house, but constructed all its interior furnishings as well. He was workman, craftsman and artisan, all in one.

The first chapter of this book has described veneering as practiced in Egypt, as Sir Gardner Wilkinson has interpreted the sculptured story. (See Illustration 1, page 5.)

Not only was veneering practiced, but the Egyptians also knew how to make imitation finishes, so that a common wood might be finished to look like a more valuable product, a fact also authenticated by Wilkinson:

> Boxes, chairs, tables, sofas, and other pieces of furniture, were frequently made of ebony, inlaid with ivory; sycamore and acacia were veneered with three layers, or ornamented with carved devices, of rare wood, applied or let into them; and a fondness for this display suggested to the Egyptians the art of painting common boards to imitate foreign varieties, so generally adopted at the present day. The colors were usually applied on a thin coating of stucco, laid smoothly on the previously prepared wood, and the various knots and grains painted upon this ground indicated the quality of the wood they intended to counterfeit.[1]

From these ancient times up to the beginning of period styles in furniture, history reveals little of the methods and tools used in the art of veneering. The workmanship of the

[1] Wilkinson, Vol. II, pp. 195–6.

surviving furniture is an interesting demonstration of marvelous craftsmanship, but it is practically all hand work, aided by simple tools and primitive methods, almost wholly individualistic in character. We know that few mechanical aids in woodworking were available until well into the 19th Century, and the meagre 17th, 18th and first half of the 19th Centuries were largely dependent on individual skill.

## Modern Methods

Even in the last decade of the past century, the Chambers' Encyclopedia describes the art as follows:

> The process of veneering consists in simply gluing the veneer to thicker wood and placing what is then virtually one solid board or panel with the veneer face downwards on a metal table heated with gas. By means of cross-bars and screws, above and below the table top, the veneer is held tightly to its backing for two or three hours, till the glue is dry and firm.[2]

A recent writer, who is a most ardent advocate of the use of plywood, outlines his impression as follows:

> The "mystery of plywood" now becomes a revelation. Plywood is the completed board or panel made up of different plies. One ply is called the core or center; to each side of this core another is glued with grain at right angles to the grain of the core; these two plies are called cross-bands; and to one of these, a fine face of veneer is glued for the upper surface and on the under side, another veneer is glued for what is called the back. The piece, thus built up and completed, made into one solid wooden structure, is called plywood.
>
> There is also, of course, 3-ply plywood built up of a core, together with a face and back. This was the only plywood construction known to the ancients, the Egyptians, the craftsmen of ancient Babylon, and the like. Plywood with five layers is distinctly and creditably the triumph of the

[2] Chambers' Encyclopedia, 1892, Vol. X, p. 448.

modern craftsman. We might almost say that it is peculiarly American, because it is American genius that has advanced it to its present height of utility, endurance and superb service.

The processes through which plywood and its parts move forward through a typical modern manufacturing plant are literally a revelation to the uninitiated. In fact, a recent visitor to a leading American factory said: "I had no idea of the extreme care and delicate caution and precaution in the marshalling of orderly processes, which characterize the manufacture of plywood as it obtains in the United States. It is an education in the accuracy, thoroughness and dependability of applied science in modern manufacture under the egis of Uncle Sam."

We must first observe, however, the one dominant keynote in reference to plywood, and that is, that no other process of manufacture combines so completely and perfectly the factors and elements which make for strength and beauty, all in one, as does plywood. Let us analyze this just for a moment. The face woods or veneers give beauty, beauty in the color and the figure of the rarest and most costly treasures of the forests. These outer layers (in 5-ply) lie parallel with the core grain within, while for reinforcement and tension resistance, plywood has the double leverage of its cross-bands, thus wedding anew the strength and beauty of nature. Solid wood splits with the grain, always did and always will. Plywood can't split. It is braced by the cross-bands, held by the glue, and these bands in turn are riveted in rigidity to the core. In one word, this is the construction that has enabled wood to make itself proof against the infirmities of wood; for it can neither warp nor twist nor bend nor change from its perfect alignment and monolithic characteristics.

This description may seem almost an apostrophe to the glory of plywood, but it is not intended as such; in proof of which we bring your attention again to the story of what goes on in a plywood plant and the way plywood is made.

## Accumulation in Storage, Ready to Glue

The veneers and cores are usually accumulated in a dry storage room adjacent to the press room. In the case of large

and intricate orders, it requires careful production control to make certain that every item has just enough and not too many pieces for its proper completion, i.e., for one hundred 5-ply tops it requires one hundred each of faces, backs, face crossings, back crossings, and cores, with reasonable allowance for waste, usually from three to five per cent. Veneer faces, particularly, are not accumulated without considerable complication, since the product of the chosen or assigned flitches may fall short or overrun the anticipated or desired number; and in either event, more flitches must be issued or the surplus assigned to other items or orders. The face veneers, and to some extent the backs, crossings and cores do not submit to the same simple quantity measures that are used for most raw materials.

Veneers, ready to lay, should be piled in dry storage rooms so that they will keep flat and straight, never piled on edge or irregularly. The temperature of veneers should be from 70° to 90° F. and they should be redried to from four to six per cent moisture content before they are glued into plywood.

The layers of face and back veneers are usually alternated in the order and position in which they are to be laid up in the press, with caul boards or with sheets of paper between the faces especially so that adjacent pieces of plywood will not be stuck together by the glue that is sometimes forced to the surface. Oiled caul boards are preferred by most manufacturers, while some utilize old newspapers.

In the case of structural panels for interior trim, or other plywood that is built in standard sizes, it is customary to maintain, in a dry storage room, a reserve supply of cores, crossings, faces and backs, which can be glued up in such combinations of sizes, thicknesses and woods as may be required.

All such accumulated stock, whether in standard sizes or especially made for individual requirements, must be most carefully tagged for identification and to prevent confusion.

## Laying up Veneer

The press room in a plywood factory, more often called a glue room, is a busy place, as every move must be made with precision, and any delay in putting fresh glued stock under pressure may weaken the glue joints.

In 5-ply work, the crossing sheets are fed through the glue spreader (See Illustration 160, page 279) and thoroughly covered on both sides with an adequate film of glue, so that one side may firmly adhere to the core and the other side to the face or back veneer. As the freshly glued cross-banding comes from the glue spreader, it is carefully placed in position by a "layer up," who sometimes wears gloves to protect his hands from the alkali in the glue. (See Illustrations 161 and 162.) With the use of some vegetable glues, the wearing of gloves is not considered necessary. Other members of the crew put a dry core, or a double layer of dry faces or backs on the cross-banding, followed by another double-glued crossing, and so on, making a somewhat loosely piled mass of plywood, freshly glued and unpressed. Illustration 161 shows such a pile separated sufficiently to establish the identity and condition of such sheet.

It is good practice to have four stock trucks adjacent to the glue spreader, one with crossings to be glue coated, one with cores, one with faces and backs and the other with suitable guides against which to jog layers of stock as the freshly glued plywood is laid up. (See Illustration 162.)

In the case of 3-ply panels, the core (lumber or veneer) is passed through the glue spreader, and covered with a film of glue on each side. In other respects, the operation is similar to 5-ply.

Some manufacturers still build 5-ply in two steps, gluing the crossings and the core into a 3-ply construction at one operation. After removing from retainers, and after glue is set, they use the combined crossings and core as the "core" of

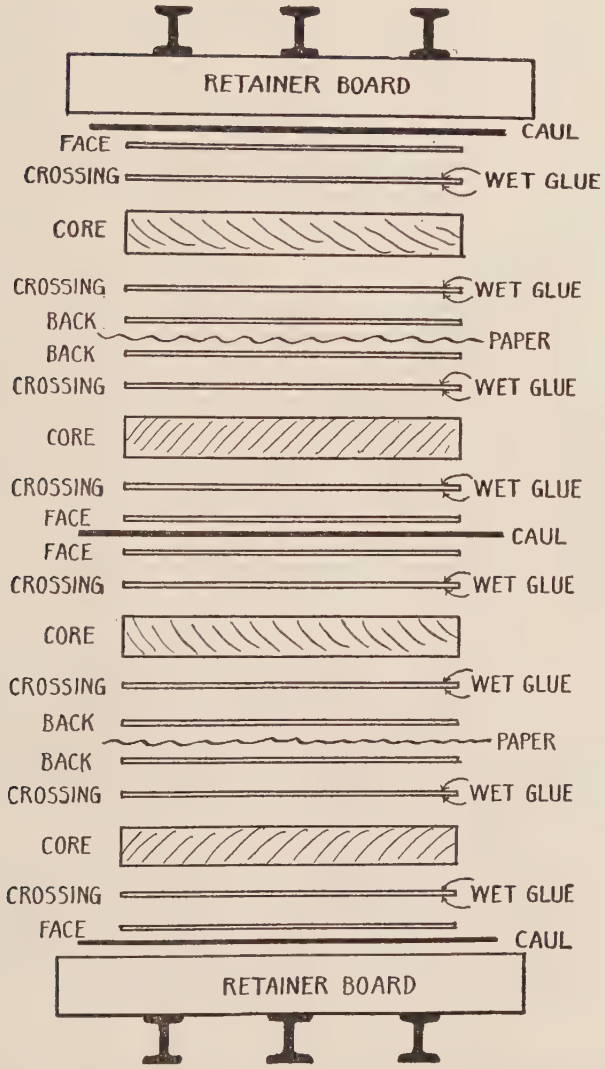


Illustration 161. Showing rotation of various layers as a retainer full of plywood "makings" is laid up in the glue room. "I" beam retainers shown at top and bottom of illustration.

the next step, making another 3-ply operation, but resulting in an ultimate 5-ply product. Care must be used not to weaken the glue joint of the first layers of veneer when performing the second operation.

The most convenient size to lay up is about 2 feet wide by 4 feet long. A competent crew will complete a greater total footage of this size than of larger or smaller sizes. In fact, smaller pieces are usually prepared two in one, three in one, four in one, etc., so as to facilitate the work of the glue room crew and to increase production throughout the plant. Larger sheets are more clumsy to handle, and slow down the gluing, pressing and clamping operations.

The "layer-up" must watch most carefully to see that every sheet is in proper position, that veneers do not "climb" nor "lap" at taped joints, that defective pieces are uncompromisingly rejected and that sufficient glue is always evenly spread over every surface. It is his responsibility to see that cauls are properly placed, that the package is of the proper height to go into the press, and that pressure is applied before the glue takes a premature set. He is really the pacemaker of the glue room crew, and is directly chargeable for any defective materials originating in his department.

Face veneers and crossings are laid, so far as possible, with the log side towards the core, to make the cutting checks less conspicuous and also make a better glue joint. The outside of the log always makes tighter surface. In matched faces, of course, it is inevitable that each alternating sheet of the veneer must be laid "other side out."

Jointed or taped face veneers are laid with taped side out, so that tape will be removed in the process of scraping or sanding. Jointed and taped crossings are laid with tape against the core, to reduce the chance of imperfect adhesion immediately under the face veneer.

When animal glue is used for plywood, it is necessary to keep the glue in the spreader at the proper temperature, to pre-

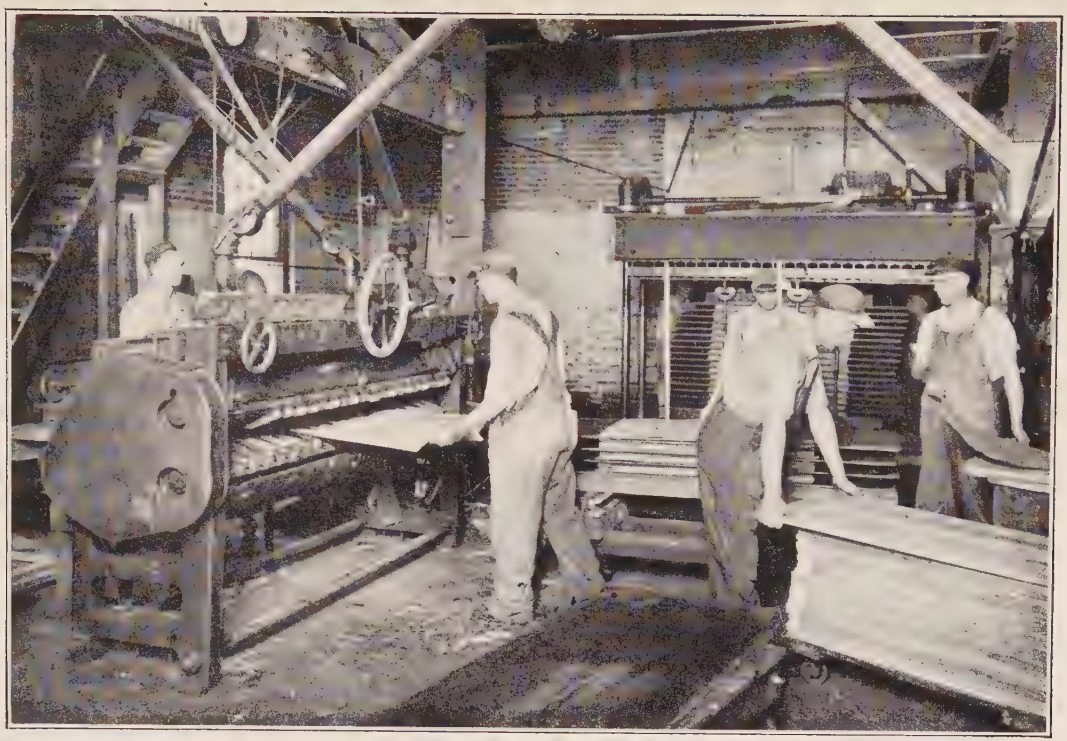

Illustration 162. Showing glue spreader at left with freshly glued cross-band just emerging. In rear is hydraulic press (upper platen electrically operated), and on truck in foreground the stock is being laid up, showing plywood caul between each unit of plywood.

Courtesy, New Albany Veneering Co.

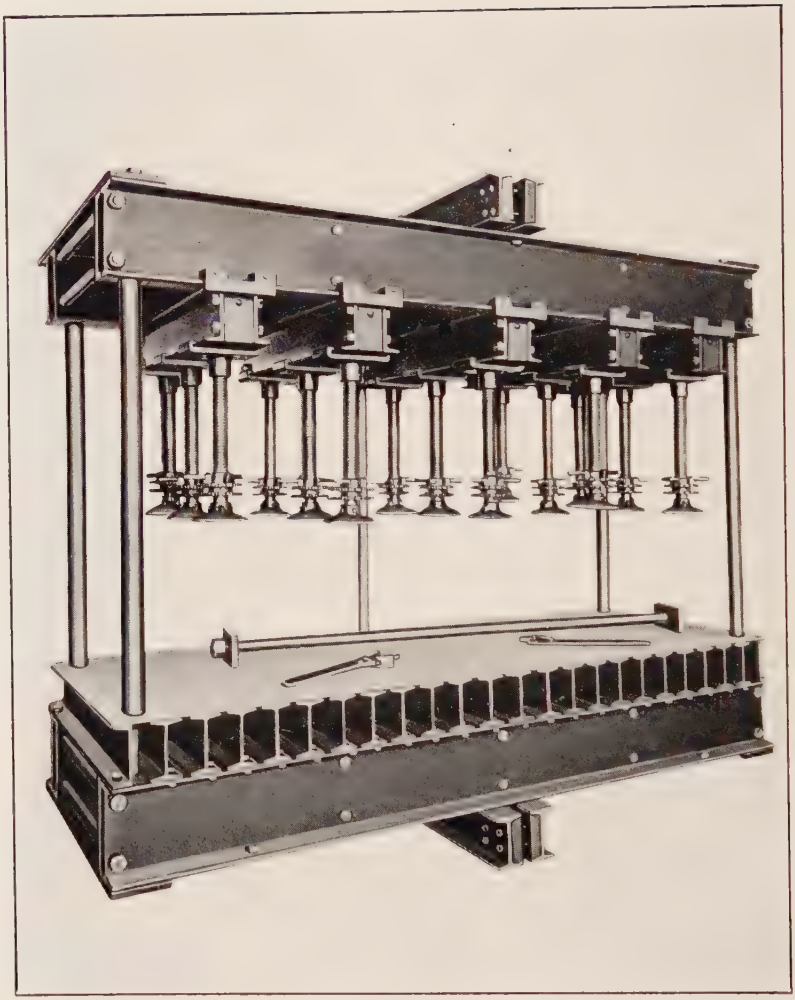

Illustration 163. Hand press for plywood, with screws receding into top frame. Long bolt on bed goes between outer center supports and is removed to give clearer view.

Courtesy, Handy Manufacturing Co.

heat all lumber and veneer to be glued, and to maintain the whole glue room at temperatures approximating 100° F. While the results of animal gluing have nearly always been satisfactory, the cost of the materials and the inconvenience and discomfort of the necessary conditions, all combine to discourage its use.

Applying glue between the edges (not surfaces) of face veneers, may be a separate operation (see Chapter XX, page 216) and may be done just as the face veneers are laid up, so that the edge and surface glue may set and dry simultaneously.

## Cauls

Cauls are large sheets of metal, fibre board, or wood, and are placed at intervals between the veneer faces to keep plywood flat and straight and to prevent any irregularities or imperfections from being communicated to adjacent layers. Some authorities advocate sheet aluminum, for its thinness, lightness and the fact that particles of glue do not readily adhere to its smooth surfaces. Others prefer a fibre board about 1/4 inch thick that must be greased or waxed to prevent glue adhesion. The wood caul, however, is the one most generally used and is considered, by many of the leading manufacturers of plywood, most satisfactory in use and superior to any other type of caul. It is claimed that in using the metal caul there is a constant danger and liability to dent the face of the caul, and this dent or uneven surface on the reverse side of the caul will protrude into the adjacent sheets of plywood. The fibre cauls have too much of a tendency to twist and warp. The wood cauls do not dent easily and do not warp. The wood caul, by many, is believed to absorb much of the moisture coming through the surface of the veneer and thus to assist somewhat in the proper drying and setting of the glue joint in the ordinary process of producing plywood. Great care must be exercised to keep cauls thoroughly clean and smooth,

as any roughness would most certainly be communicated to face veneer before glue has set.

There are many theories and practices in the use of cauls, some manufacturers claiming their lumber cores are so well made that the entire retainer full of plywood will be flat and true. At the other extreme are those who consider it essential to place a caul between each pair of faces, as shown in Illustration 161. This is undoubtedly the best practice, and beyond question the best plywood is produced by this latter method. However, it is expensive in the number of cauls required and in that it reduces the number of plywood pieces which can be placed in each "retainer package."

When animal glue was used more extensively in plywood gluing it was customary to use cauls against each face or back, and to preheat these cauls in a "caul-box" to such a temperature that they would assist in the speedy drying of the glue and still not be so hot as to burn the veneer or be too hot to handle.

## Retainers

Just before the glue room crew commence to lay up the glued stock they put a thick (3 to 4 inches) retainer board or blank caul (larger than the stock to be glued) on the truck operating between glue spreader and hydraulic press bed.

This retainer board is to be the base of the press full of glued stock and a like retainer board will be placed on top, the two to be firmly clamped together by means of outside "I" beams and retainer rods previous to removal from press. This package of glued stock (between the retainer boards) is not opened until the day succeeding the actual gluing, at which time the glue should be sufficiently dry to adhere, even if not dry enough to trim and sand.

A retainer board is virtually an exceedingly thick caul, usually made of 5-ply laminated boards, each layer at right angles to the adjacent ply. It must be stiff enough not to bend

under the clamping action, and rugged enough to endure rough handling when packages are dumped from dry kiln trucks or handled by overhead traveling cranes.

Retainer clamps are of two forms, one an "I" beam and the other a double channel iron with spaces or spreaders be-

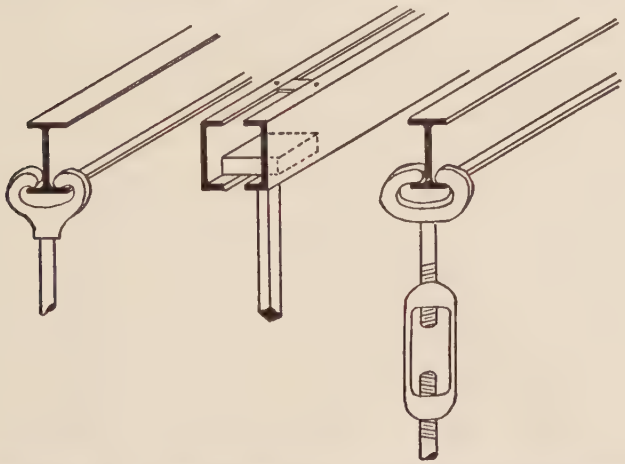

Illustration 164. Types of retainer clamps and bolts; square shank to be turned with wrench, or round shank equipped with turn buckles.

tween, both used, with various bolt clamping arrangements, several of which are suggested in Illustration 164.

The double channel retainer clamp is less frequently used than the "I" beam type.

When tightening retainer rods in press, care should be exercised to exert an even pressure all around, to maintain the same degree given by the press, and so make the retainer equipment live up to its name; i.e., "retaining" the exact uniform pressure produced by the press.

## Veneer Presses

There are three principal types, the hand presses in various forms, the power screw press (usually of toggle-joint form) and the hydraulic press.

Hand Operated. These are still used to a considerable extent in small shops, and for special work in large shops where limited quantity will not permit the use of the power press and retainer equipment, and for large or irregularly shaped plywood that will not go into the ordinary power press. Retainers and cauls should be used as in the case of power presses. A typical hand press is shown in Illustration 163, some being built in separate units and others combined to make a multiple press.

Screw Power. This type may either be like the hand press but tightened by power, as shown in Illustration 165*a*, or it may be of the toggle-joint type shown in Illustration 165*b*. The latter is one of the earlier types of power presses, used chiefly in the older plywood factories.

Since the toggle-joint is one of the most effective applications of pressure, this type of press is quite economical of driving power. However, it does not have as wide nor as uniform a distribution of applied pressure, and may not, in all cases, be the equal of other types with greater distribution in application of pressure. No ready means exist to calculate or compute average pressure per square inch on this type of press.

Hydraulic Power. This is the modern and most uniformly efficient type of veneer press. It may have as many plungers as necessary to distribute the pressure uniformly and may be operated for any degree of pressure desired, since the relation between plunger and platen pressure may be easily computed.

The top platen of this type of press is rigidly attached to the base by means of heavy steel corner posts, and the plunger (or plungers) operates through the base, forcing the lower platen upwards. (See Illustration 166.) Large special hydraulic presses were built for war work, in which the individual rams may be operated separately or together.

In a few modern plywood plants, a special double acting

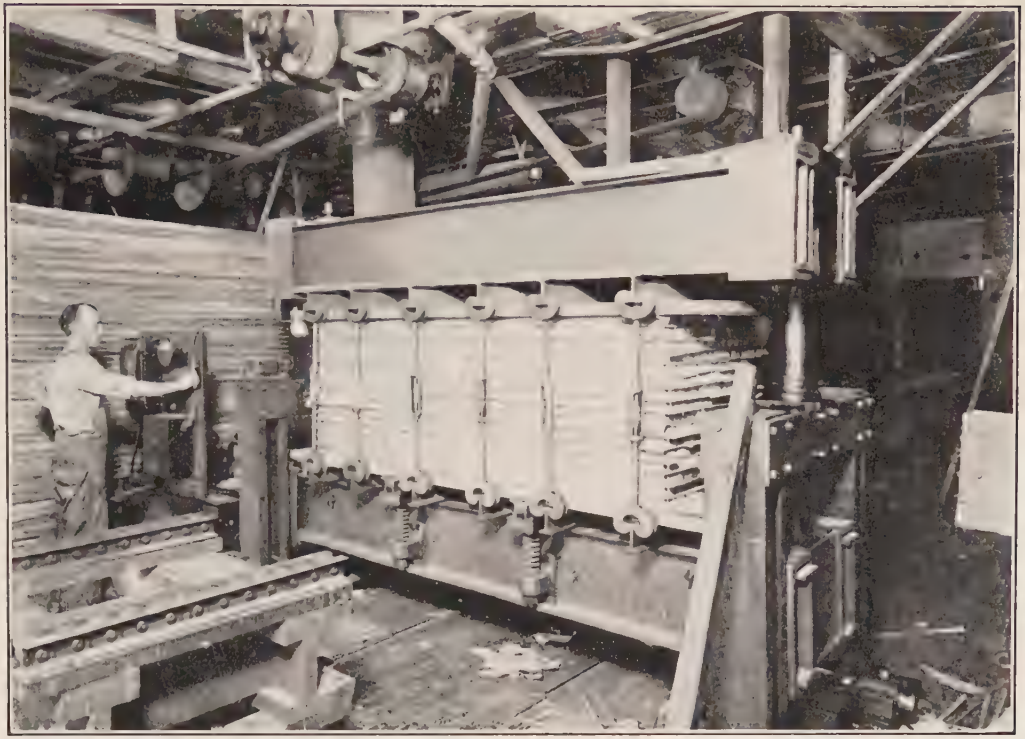

Illustration 165*a*. Showing a type of direct acting screw press, with motor-driven screws. Made also with four screws.

Courtesy, Black Bros. Co.

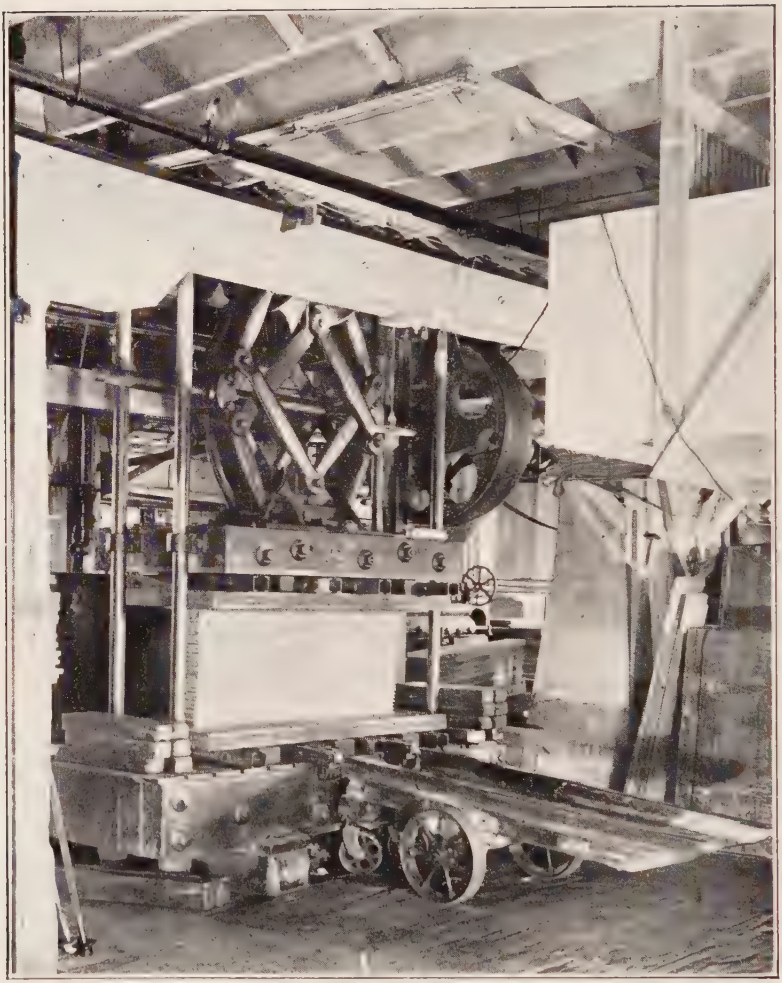

Illustration 165*b*. Toggle-joint screw press, with delivery truck for removal of clamped retainer of freshly glued stock.

Courtesy, Grand Rapids Veneer Works.

press is used. The bottom platen is forced upward by means of hydraulic power, and the top platen is lowered and raised by means of large gear or cog wheels driven by electric motor power. Such equipment eliminates the use of blocks or additional blank cauls in the pressing of other than standard height "packages" of plywood and also operates much more rapidly than the ordinary hydraulic press. (See Illustration 162.)

The unclamped retainers loaded with freshly glued plywood are usually rolled or slid from the truck to the lower platen, over roller loading ways. Both lower and upper platens are recessed for retainer clamps, which may be inserted before or during the application of pressure. While the pressure in the hydraulic ram is reaching the desired point, as shown by prepared schedule, the heads of the retainer rods are inserted at ends of retainer clamps and by means of turn buckles tightened with hand wrenches after proper pressure has been reached.

After releasing hydraulic platens, the clamped package is rolled onto a truck, or carried by an overhead crane to a room where proper atmospheric conditions can be maintained until the retainers are opened on the following day. Considerable glue is squeezed out between the veneers and this must be dried out promptly.

The retainer boards, and all cauls, should be thoroughly cleaned and scraped before being used again, since small particles of hardened glue can do serious damage to the face veneers of the package of plywood, for which they are used.

Steam-Heated Platen Presses. In the use of blood albumin glue, where plywood joints are to be made thoroughly waterproof, it is necessary to set the glue both with pressure and heat. The proper coagulation of the glue is not accomplished under 160° F. Practically, it is necessary to have platen temperatures of 200° to 220°, higher temperatures being likely to turn the moisture of wood and glue into steam. When 1/16 inch face veneer is used, three to five minutes at

212° are necessary to make a good joint. Only the two outside layers of blood albumin glue can be coagulated simultaneously, since the heat will penetrate slowly more than 1/16 inch thickness of veneer on either side, when more than two thicknesses are coagulating, thus greatly reducing the press output.

Under these conditions, only two glue layers can be made at a time, resulting in 3-ply: using this 3-ply as a core, additional veneers may be applied, making the result of the next gluing, 5-ply, and so on to 7-ply, 9-ply and as many plies as are required.

Pressing plywood singly, even in the multiple platen presses, shown in Illustration 167, is a slow and expensive process, and this method is utilized only where waterproof qualities are essential and worth the extra labor.

## Calculating Veneer Pressure

The best plywood joints are secured when the pressure per square inch is neither too great nor too little, as both extremes tend to weaken the joints. Various species of wood and glues of different ingredients and viscosities require quite a range of pressure to give the best results. In general, 75 to 100 pounds per square inch of plywood surface is an average rule that covers most ordinary work.

The formula for calculation of the proper gauge pressures is as follows:

$$\text{Gauge pressure} = \frac{\text{Pounds per sq. in.} \times \text{plywood area in sq. in.}}{\text{Area of hydraulic piston in sq. in.}}$$

Charts or tables should be prepared for easy reference in glue room, showing required gauge pressure for plywood of different areas, and also for different varieties of work.

## Curved and Shaped Dies and Cauls

The different steps of veneer preparation for curved work are essentially the same as those explained for flat work, ex-

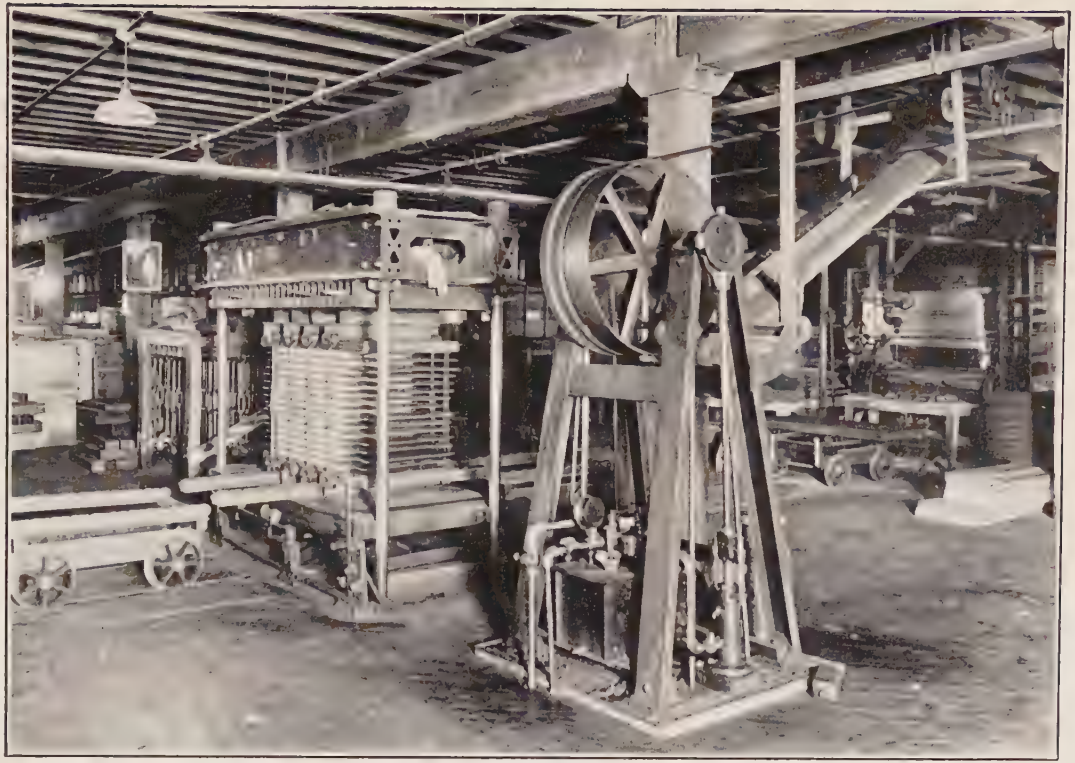

Illustration 166. Showing hydraulic plywood press and pump, with glue spreader and lay-up truck at extreme right.

Courtesy, Chas. E. Francis & Co.

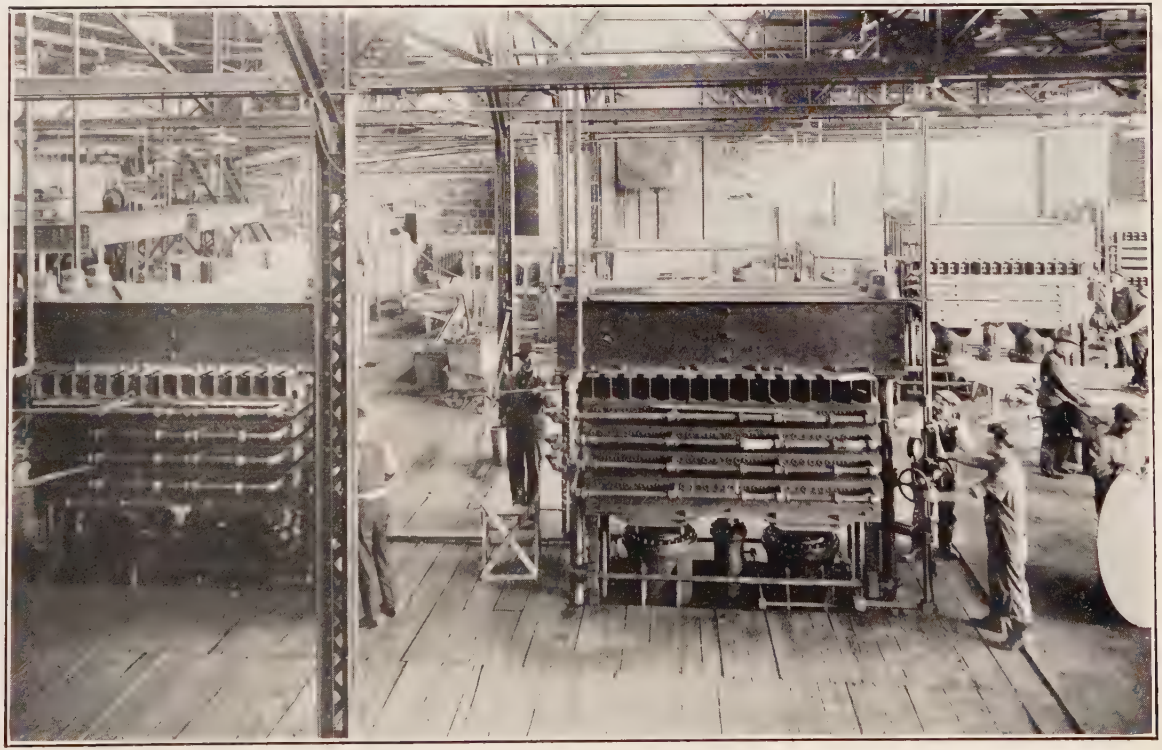

Illustration 167. Showing multiple platen hydraulic press with steam-heated platens, designed especially for using blood albumin glue. One unit of plywood only can be placed between each pair of platens.

Courtesy, Haskelite Co.

cept that figured veneers are seldom used in curved work, and the use of taped veneer joints must be avoided as much as possible. The glue spreading operation is not different from the procedure in flat work.

The retainers and cauls, however, present a different problem, since all parts of curved plywood must be subjected to approximately uniform pressure, and it is desired to utilize each press full (hydraulic presses usually open 42 inches) for as many plywood units as possible. A set of aluminum cauls and dies as used for opera seat backs is shown in Illustration 168.

A metal form has been used to secure greater rigidity than wood, and the surplus metal has been cored out to reduce weight. The inner faces of the cauls can be more accurately machined from metal than from wood, and the surfaces are not liable to dent nor change in shape under hard usage.

The aluminum cauls are calculated to produce perfect curves of each unit of the plywood back of an anticipated unit thickness and a necessarily predetermined total thickness of pressed veneer between the cauls. The radius of the top of the press and the radius of the bottom of the press being computed from the aggregate thickness of back units to be pressed in the particular form, with due allowance for direction of pressure so that when all sheets of veneer contained within the forms are compressed, each unit will form a perfect curve and the glue will hold fast at every point of each surface, the unit of back in top of nest having the shortest radius, the radius lengthening with each unit and the bottom having the longest radius. This slight difference in radius will accommodate different size seats, and at best is not very great.

The forms may be designed to press up units of different thicknesses. That is, the forms may be made so that a given number of 5/16 or 3/8 or 5/8 inch thicknesses may be perfectly pressed to shape throughout the entire surface area at every point. As an illustration, the cauls are designed to accommodate twelve units of 5/16 inch thickness, making a total

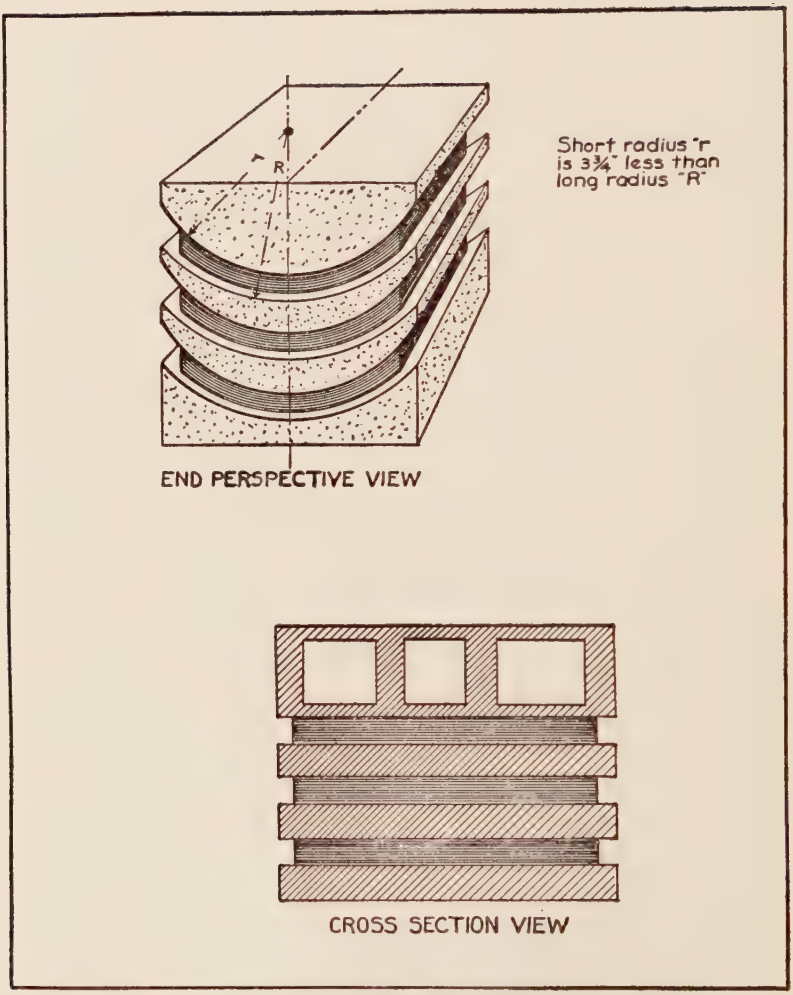


Illustration 168. Set of aluminum cauls for pressing together curved plywood opera seat backs. The inner and outer curves of package 3 3/4 inches thick are segments of circles with a common center. This set can be used with ordinary flat retainers and in standard press, as shown in Illustrations 163 to 166, inclusive.

thickness of pressed wood of 3-3/4 inches. In this case the radius of the largest back is 3-7/16 inches longer than the smallest back, so that the total thickness of veneer sheets within will be formed up perfectly and the glue held fast throughout the entire surface from edge to edge. If the attempt should be made to use in these forms, say five 1/2 inch units, it will not produce plywood of either perfect form or secure glue pressure throughout the area at every point. The result will be irregular curves and loose glue in the forms or perhaps actual breakage of the forms themselves. The principal defect would be in failure to secure glue pressure right out to all edges, which would result later in unglued surfaces. It is to be noted, however, that the total thickness, 3-3/4 inches will accommodate twelve sheets of plywood 5/16 inch thick, or ten sheets 3/8 inch thick or six sheets 5/8 inch thick.

Other curved shapes are similarly laid up, although the difficulty of making proper forms increases with the sharpness of the curves and the intricacy of compound and reversed curves.

When the freshly glued sheets of veneer are laid up in these curved forms, the instability of the pile is noticeable and the succeeding layers are likely to become displaced. This is especially true in reversed curves, where nesting of cauls is not as possible as in simple curves.

The flat heavy retainers, previously used, may again be used outside of these metal cauls and the packages clamped and dried in the usual way. Sheets of waxed paper should be placed as separators between curved plywood units to permit easy removal from cauls.

Concave and convex plywood for wardrobe trunk tops, etc., may be pressed into shape in similar sets of dies, but the degree of convexity or concavity cannot be very great without either tearing veneer apart at the center of the sheet, or crinkling it at the edges.

The proper production or equipment for curved plywood is too large a subject to be more than outlined here.

# CHAPTER XXVII

## COMPLETION OF GLUED STOCK

### Drying the Water from the Glue

Plywood should be left in the retainers not less than six hours, and it is usual factory practice not to open the retainers until the succeeding day after gluing. The surface moisture from the glue, squeezed out between the layers in pressing, should be dried out by piling loaded retainers in a room where drying conditions are active, either by heat or mechanical ventilation, or both, as shown in Illustration 169.

As the sheets of plywood are removed from the retainers, they should be piled on sticks on trucks, using sticks of exactly uniform thickness and width, and great care should be exercised to the end that each stick is placed directly above the one below it. Otherwise the various items of plywood will not come from the drying room flat and straight. It is also good practice to place heavy steel weights on the top of the plywood package going into the drying room, as plywood dried flat will remain flat, a very essential attribute in finished plywood.

In a modern and highly efficient plywood drying room, "green" plywood may be dried to less than eight per cent moisture content in 24 hours, at a temperature of 110° to 120° F. and with the humidity at forty to forty-two per cent. However, in order to eliminate the large amount of moisture from green plywood in such 24 hour period, it is necessary to force the circulation of air in the kilns or drying rooms by means of large vacuum fans. Such artificial circulation acts somewhat in the nature of a March wind, and the natural drying process is very materially augmented and hastened. Unless the glued stock is redried in this manner, veneers may peel

Illustration 169. Showing 5-ply stock, removed from retainers, arranged in piles with stickers, and placed in a redryer to remove the moisture reintroduced into wood by the glue.

Courtesy, New Albany Veneering Co.

Illustration 170. Showing double cut-off saw, chain feed type, trimming both ends of plywood in one operation.

Courtesy, Underwood Veneer Co.

Illustration 171. Sanding machine used to smooth off plywood surfaces after glued and cut to size. Made in both endless bed and drum types

Courtesy, Underwood Veneer Co.

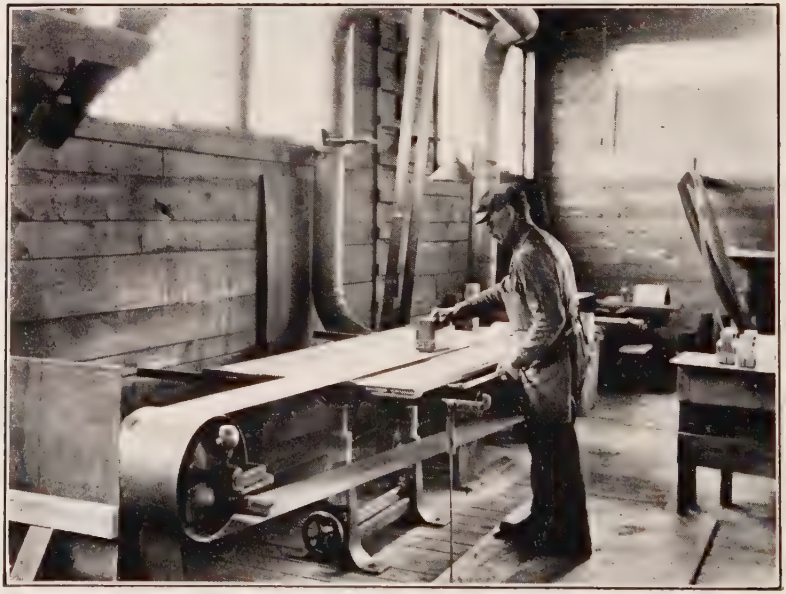

Illustration 172. Belt sanding machine, used for final sanding and cleaning up of plywood.

Courtesy, Underwood Veneer Co.

loose in trimming or the plywood may warp, and the face veneers possibly may blister in the process of scraping or sanding.

The water (from fluid glue) reintroduced into 5-ply, per square foot of plywood, may be easily calculated by making the following conservative assumptions:

Glue mixture.....1 lb. dry glue and 2½ lbs. water.
Fluid glue spread.....40 sq. ft. per lb. dry glue.
Four glue strata.....10 sq. ft. (5-ply) per lb. dry glue or 4 sq. ft. per lb. water.
One pound water.....231 cu. in. per gal. ÷ 8.3356 lbs. = 27.7 cu. in. per lb.
Water per square foot plywood...27.7 ÷ 4 = 6.9 lb.
Equivalent to.....048 in. water in pan 1 ft. square, 1/20 in. deep, approximately per sq. ft. plywood.

This is equivalent to an ordinary size tumbler of water (approximately 1 pint) per 4 square feet of plywood.

The different kinds of plywood should not be mixed in the same charge of operation. Plywood with veneer cores needs this redrying more than that made with lumber cores, since the latter have more absorption capacity.

## Trimming

The plywood, built to gross dimension, with rough edges, is sawed, edges and ends, to final size, which is often slightly over customer's sizes to allow for final squaring and fitting in assembly. In the case of random face figure, no especial care is needed to balance the amount cut from each edge, but in center-matched faces and four-piece stump work, as well as in plywood built double for width and length, it is necessary to measure or indicate the saw cuts with reference to face joints. Adjustable pointers suspended over saw table are frequently used to facilitate this work. Double cut-off saws with chain feed are useful in maintaining uniform sizes, as shown in Illustration 170.

## Sanding Surfaces

This is the most delicate step in the completion of plywood, since face veneers are frequently made of 1/28 inch veneer and it is difficult not to "sand through" if plywood is warped, or uneven in thickness, or some protuberance of core or crossing has been pressed into the face during the gluing process. Endless bed or roll feed (drum) sanders with two, three, or four drums are used, as shown in Illustration 171. Each surface must be sanded separately, except that in the case of plywood doors, door-panels, or other products with thick veneer faces (1/16 inch, 1/12 inch, etc.), it is possible to combine the sanding of both sides in one machine. The sandpaper is coarsest on the first sandpaper roller, with increasing degrees of fineness, until the final roller has a polishing sandpaper, calculated to produce a surface ready to fill or stain.

The paper tape, used to hold face veneers together before gluing, is removed in this sanding process, and the joints between the edges of two pieces of veneer should be imperceptible, except as an invisible line at which the grain or figure of the veneer changes its direction. Two sheets of veneer which have been reversed to balance the figure, may appear after sanding to be different colors or different shades of the same color. When viewed in different lights, the markings show a wide variety of effects, that is most interesting to the connoisseur, but is sometimes censured by the uninitiated as bad matching. These elusive and fugitive shadings are most attractive and artistic, and deserve more general popular appreciation.

After machine sanding, the inspectors will find some pieces of plywood from which remnants of tape have not been removed or rough spots of the veneer have not been cleaned off, and the final touching up will be done by means of a belt sander, shown in Illustration 172. The movable pad may be pressed down over any spot to such a degree as is necessary to leave a clean smooth surface.

The lustre, polish, and smoothness of a varnish, enamel, or lacquer finish depend to a large degree on the perfection of the final sanding operation. Veneer that is sanded too thin will not finish well, and the glue may show through.

## Scraping

Another method of cleaning off the tape and smoothing to a surface the face veneer, is by scraping. The scraping machine removes less veneer and leaves a much more even surface and one in which the pores are not filled with sandpaper dust. Except for straight grained face veneers, however, the scraper is liable to tear out small sections. The scraping method of surfacing is more appropriate for solid hardwood flooring where it is extensively used. Yet in many modern plywood plants, the scraping machine is successfully and satisfactorily operated.

## Moulded Edges

Plywood in which the edge of the lumber core is exposed, is said to have "raw" edges, and in many locations this is not

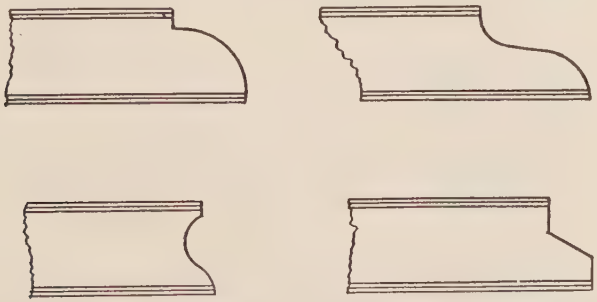

Illustration 173. Showing shapes of moulded edges on table and cabinet tops.

objectionable. Table tops which have banded or railed cores are frequently moulded on the edge to some of the shapes shown in Illustration 173. It will be noticed that most of the

shapes shown are so proportioned as to make the end and edge exposure of face veneer and crossing as inconspicuous as possible. This moulding or shaping is sometimes done before the sanding operation and is frequently considered a function of the plywood factory.

## Edge Veneering

Another method of improving the raw edges of table and cabinet plywood tops is to veneer the edges. In the case of rectangular tops this is merely a process of gluing and clamping of thin strips of veneer on each edge, trimming off the surplus with a small trimming saw, made especially for the purpose. (See Illustration 174). The edge veneering is done before sanding, and the remainder of the edge veneer, after saw trimming, is cleaned off in the sanding operation.

When table tops are cut to shape, it is customary to save the outer curved piece so cut off and to use it as a form in clamping the edge veneer in place. The saw kerf from the operation of band-sawing leaves just space enough for the veneer.

It is occasionally desirable to have the grain of the edge veneers vertical, instead of horizontal, in which cases several tops are stacked up, with 1/4 inch strips between, the edges veneered "en bloc," and the individual tops cut apart with a sharp knife before saw trimming and sanding.

## Repairing

A veneer and plywood hospital is essential to salvage the work that suffers slight damage in passing through the many mechanical operations outlined herein. When such patching is skilfully done, the resulting plywood is none the worse for it, since tight matching and sound glue joints are as strong as the wood itself.

Illustration 174. Showing edge veneer trimmer, electrically operated, removing surplus edge veneer before surface sanding.

Courtesy, Mattison Machine Works.

Hair lines and open joints in face veneers bring gray hairs to plywood makers. The causes are various, among which are:

Green face veneers
Rough veneer jointing
Poor taping
Defective cross-banding
Failure to glue joints properly in face veneer

Little can be done to produce an effective remedy, except to prevent a recurrence by vigorous corrective methods. Extra finishing precautions will help some, but the expert will not be misled.

Many instances of open face veneer joints and loose veneer are laid at the door of the plywood maker and do not belong to him at all. Stains, fillers and various finishes may be so applied as to dissolve the glue. Dipping small plywood articles in water stains is a prolific cause of grief. Some spirit and oil stains are damaging. Usually the best remedy is to use a stain less generously. Any soaking is bad, drippings should be promptly wiped off and all accumulations of stain removed.

Glue joints need not be harmed by any of the better stain solutions, providing the application is done intelligently. But the finisher must exercise as diligent attention to detail as does the plywood maker.

Eternal vigilance is the price, not only of liberty, but of good workmanship in every branch of the plywood industry.

## Crating and Shipping

When plywood is packed for shipping it is customary to lay the faces towards each other, leaving only the backs exposed. All dust particles on faces should be carefully brushed off, as many scratches may be traced to carelessness in this regard. Plywood "in the white," before finishing, is most

susceptible to moisture absorption, and should be stored in a dry, warm room. If shipping is likely to mean exposure to dampness, crates should be lined with waxed paper.

## Inspection

Plywood should be frequently inspected during its manufacturing progress both to detect faulty material and to remedy poor workmanship, as well as to correct and adjust machinery which is not functioning efficiently. The best modern practice (and by many plywood manufacturers claimed the most economical) is to inspect and to select carefully all raw materials entering into the making of plywood, as only by such careful inspection and selection is it possible always to insure the best in plywood production. Regular inspections are necessary if plywood makers are to expect among workmen the proper development of a pride in quality. There is something fascinating in the smell, the touch and in the appearance of the best veneered work which appeals to an earnest worker and spurs him on to his best endeavors in the production of a meritorious product. A real woodworker needs to love his trade and no mechanical devices nor production controls can in any way equal the genuine artistry of wood workmanship. Who has not seen a lover of wood work caress the product of his craftsmanship and at the same time express almost a human love for its perfection?

# CHAPTER XXVIII

## MARQUETRY AND INLAYS

### Terms Used

Marquetry and inlay seem to be the modern terms covering a rather wide range of artistic effects in veneer. The word *marquetry,* comes from the French "marqueter," to spot, to mark; and refers especially to the practice of cutting several sheets of differently colored thin wood veneers placed together in the same design, so that by one cutting, eight or ten copies of different colors may be produced which will fit into each other, and only require subsequent arranging and gluing.

*Intarsia* is an older term than *inlay* and particularly applies to the ancient process in which a space is hollowed out of a solid base wood, and afterwards filled with a piece of valuable wood, metal or precious stones. Much of the early inlaid work was of this character, giving the same appearance as veneer. "Inlaid with precious metals and ivory" is a phrase descriptive of a multitude of examples of ancient craftsmanship, many of which have been mentioned in the historical section of this volume. No attempt will be made to duplicate this information here, but some of the methods of workmanship revealed by history and some modern examples of similar artistic effects will be outlined.

The term *parquetry* refers especially to geometrical designs, largely squares and diamonds, and is rather more typical of floors and panelling than of furniture, although it appears from time to time in furniture designs.

The result obtained by these various methods of inserting designs was to present an even flush surface that could be fin-

ished and rubbed to a high polish, and that was both pleasing to the eye and smooth enough to be impervious to dust, as well as to permit easy cleaning, to preserve the delicate lines, and to be durable enough to stand the strain of use.

## Historic Description

An old German book of 1669 gives a rather interesting account of the methods of early decorative work which fall strictly within the limits of marquetry:

> Woodworkers paint with quite thin little bits of wood, which are colored in different ways, and the same are put together after the form of the design in hollowed-out panels, fastened with glue and polished with an iron on the surface so that they may become quite smooth. They paint at the present time in this manner tables and jewel chests or trays, and all in the highest artistic manner. Also separate pictures are put together, which copy the works of the most celebrated masters. First, they take small, very thin pieces of pear or lime dyed through with different color-stuffs, which are prepared by certain processes, so that the wood is the same color within and without. Then they give them their several shapes as the kind of picture requires, cutting them according to the size and shape, and stick them with glue on the board. In the place of wood, they sometimes use bone, horn and tortoise-shell cut into fine strips, also ivory and silver. The whole work is called by the Germans "Einlegen" or "Furnieren," because although each piece is separate from the others, no part is taken out from the surface in which such figures are inlaid, but the whole is covered.[1]

## Buhl or Boule Work

One of the famous early exponents of the art was André Charles Boule (1642-1732), who was called a "royal marqueter in wood." The English term "buhl" is derived from

[1] Quoted by Jackson, pp. 106–7.

his name and is applied to the particular style of inlaying furniture with metal over tortoise-shell which he originated.

## Technique of Cutting Marquetry

Marquetry rose to its highest form in France during the reigns of Louis XIV and Louis XV. The following excellent description of the art of cutting marquetry patterns is quoted, and it suggests the earlier methods, which were far more primitive:

> A tracing of the design is glued on to the sheet of veneer which is to form the ground, and other veneers to form the design are glued on the back with paper between them. They are then cut on what is known as a "donkey," which is a stool with the frame fixed at the end, on which the saw runs horizontally, and to which is also attached the upright clamp, something like a harness maker's, worked with a treadle. The cutter sits astride the stool, holds the veneers in the clamp, and moves them about with his left hand, whilst he works the saw with the right. The saw frame can be adjusted so as to cut on the slope and insure a good fit. Marquetry cutters are generally men who do nothing else, thus becoming highly skilful in the work, and as a rule they make their own saws, which are extremely fine, out of clock spring steel. When the cutting is done, the design is laid out on a board, and the pieces shaded where required. This shading, which is really scorching, is done by dipping the veneer into hot sand, and when completed the whole design is glued down on to paper, and handed over to the cabinet-maker to lay. If any engraving is required, it is done when the marquetry is cleaned off. Veneers are now stained in all colors, so that it is possible to obtain very naturalistic effects in a flower design. . . . The fans, shells, etc. . . . are cut and shaded in the manner described above.[2]

To make it clearer how the angling or sloping saw cut of the marquetry cutting permits such close fitting of designs,

[2] "Modern Cabinet Work," by Percy A. Wells and John Hooper. Rev. ed., published by J. B. Lippincott Company, Philadelphia, 1922, p. 386.

an enlarged sectional view of such a pair of veneers is shown in Illustration 175. Several pairs of veneer sheets can be cut simultaneously, the pieces of each pair fitting together.

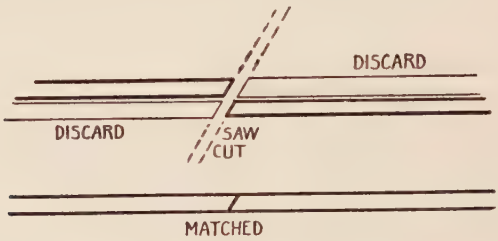


Illustration 175. Showing how the principle of angle sawing in marquetry cutting permits close-fitting shapes.

## Inlaid Borders

Much of the modern inlay is made in narrow strips, of single and contrasting colors, glued together like very delicate mouldings. Several patterns are shown in Illustration 176. These are set into doors, table tops, and the like, after the suitable recess has been cut with a router. The routing machine is mounted on a flexible arm with a wide swing. (See Illustration 177.) The patterns for a router are frequently metal or thin wood. These strings or bands of inlay can be bent around curves as well as mitred and jointed for sharp angles.

The skilful use of these borders adds much to the symmetry and grace of furniture and interior trim. This inlay routing is usually done after the glued plywood leaves the retainers in the glue room, and before the pieces are trimmed and sanded.

Much more complete descriptions of this fascinating and attractive work are contained in several published works included in the bibliography at the end of this volume.

## Appliqués or Overlays

These are raised or relief panels or veneered shapes, frequently of burls or rare figured woods. They vary from 1/32

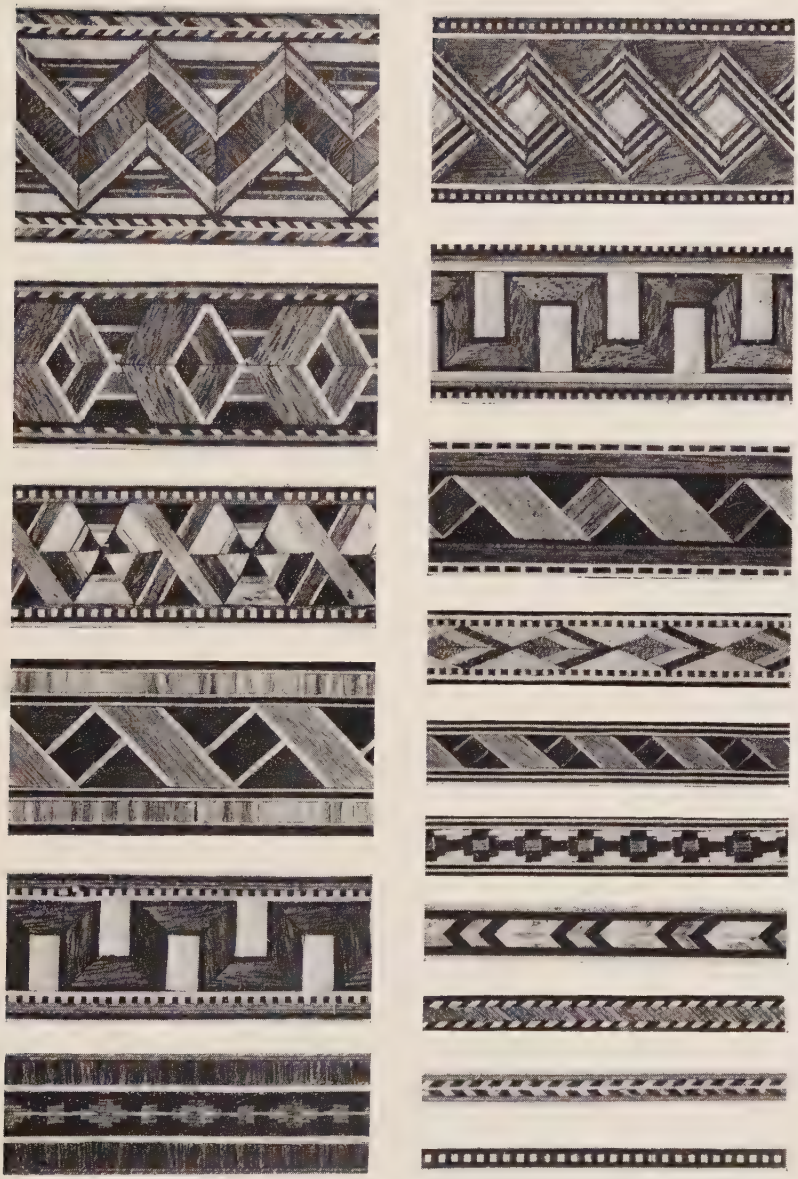

Illustration 176. Showing various marquetry borders of different colored woods.

Courtesy, Marqueterie Importing Corporation.

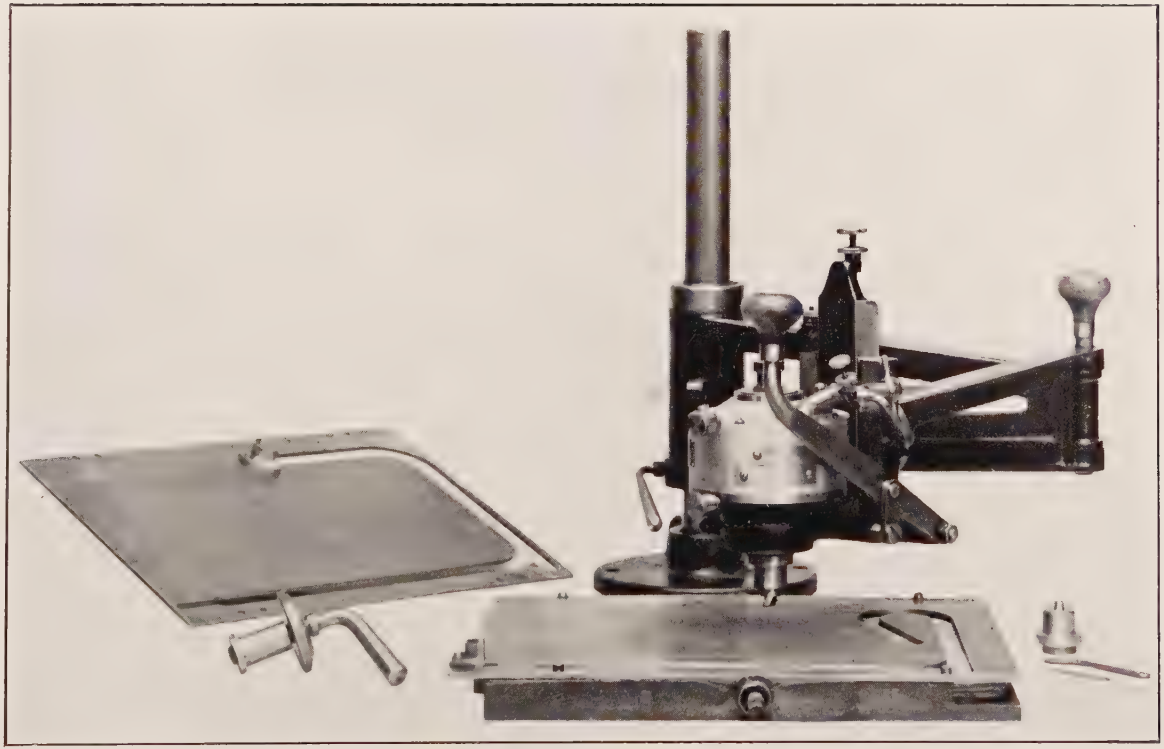

Illustration 177. Type of routing machine to cut out groove for inlaying. Metal pattern usually required. Cutter revolves at high speed driven either pneumatically or electrically.

Courtesy, Onsrud Machine Works.

Illustration 178. Showing appliqué border, raised above face veneer. Sometimes called overlay, or onlay.

Courtesy, Berkey & Gay Furniture Co.

to 1/8 inch in thickness. Care must be used in gluing, to prevent weakening the glue layers in the veneers underneath. Polishing and rubbing around these overlays is difficult, but the shadow line effect is highly prized by designers. Overlays are cut in many forms and shapes, frequently into circles, ovals, diamonds, stars, and the like. (See Illustration 178.)

The raised and moulded plastic ornaments used on some of the moderately priced suites of furniture are in no way to be confused with genuine veneer overlays.

# CHAPTER XXIX

## VARIATIONS IN PLYWOOD CONSTRUCTION

The various types of plywood construction may be divided into four general classes, although the border line between is somewhat elastic. Illustrations 179 and 180 show the more usual types in each class.

Lumber core plywood
Veneer core plywood
Plywood with equal plies
Flexible and bent plywood

No attempt will be made to make critical comparison between these classes, but a general description will be given, indicating the main reasons for each type of construction.

### Lumber Core Plywood (5-ply)

This is the construction commonly known as "top" and is usually made in 5-ply, with thickness varying from 1/2 to 7/8 inch. Writing beds for desks, and flush (or sanitary) doors are from 1-1/8 to 1-7/8 inch. The thickness of face veneers in plywood, aggregating less than 1 inch in thickness, are customarily 1/28 inch in figured wood, walnut, mahogany, etc. Better plywood results from the use of 1/24 inch, since there is less danger of sanding through and there is more body to the veneer. The standard thickness of walnut and mahogany face veneer is 1/28 inch, however, and most 1/24 inch veneer is cut on special order. In birch, maple, gum and similar woods, face veneers are usually 1/20 inch. Plain, rotary and quarter sawn oak are usually 1/20 inch—however, for special purposes, both kinds are frequently cut 1/16 inch thick. For exceptionally special and high grade plywood, the face and

back veneers should be of the same thickness, and preferably of the same wood, the face rejects often serving for backs. However, the practice of using a wood of different species

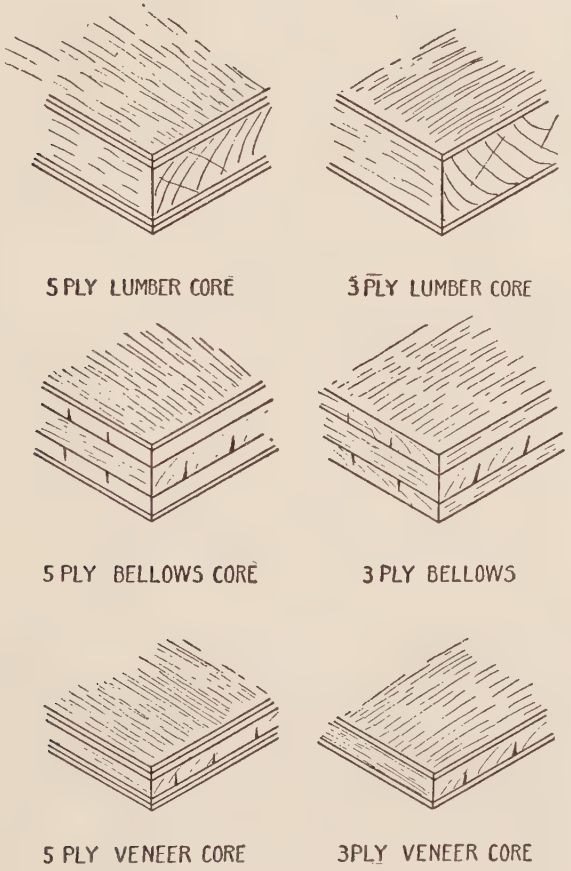


Illustration 179. Showing various types of plywood construction with different plies and cores.

and thickness for backs is quite extensively followed and, except occasionally in very particular plywood constructions, with very satisfactory results.

The cross-bandings are customarily 1/20 inch in thickness, although some makers prefer 1/16 and some 1/24 inch. The

latter are liable to split and tear in the glue spreader, but either 1/16 or 1/20 inch is approved practice. Poplar and tupelo gum are used for crossings more than any other woods; chiefly because these woods dry reasonably flat and straight, also because each of these woods, and more particularly poplar, are popularly believed to make more satisfactory glue

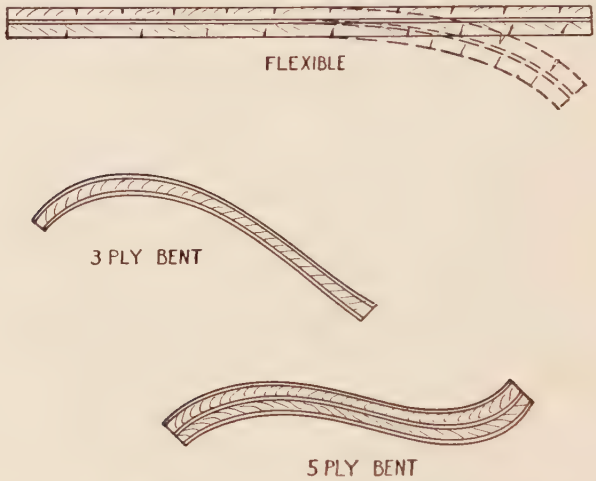


Illustration 180. Flexible and curved plywood showing relation of thicknesses and bending. Bending with the grain is easy and possible on thick veneer. Bending against the grain should be only on thin veneer.

joints than will some of the other woods; also largely because of their reasonable cost. Some plywood authorities advocate harder texture wood for crossings, claiming a firmer base for the face veneer, and a greater resistance to bruising and denting in the finished plywood, as used in furniture and pianos. The harder texture woods, such as gum, maple, birch, oak and the like, do not take glue quite as readily as the poplar and tupelo. The argument for a firmer base under face veneers has some merit. Face and back crossings should, of course, be of the same species and thickness. No attempt is made to cut crossings as "tight" as face veneers should be cut.

Crossings are preferably "one-piece" under faces without

tape, the "piece-crossings" being taped up to use under backs. Every joint in a crossing is a hazard, since uneven thickness, an open joint, or other defect will most certainly show through the very thin face veneer, particularly after finishing and polishing.

The three favorite woods for lumber cores are chestnut, poplar and gum, although many other woods may be safely used. Mixed woods should not be used in the same core, however. Lumber cores are seldom made less than 5/16 inch in thickness, below which point it is customary to use rotary cut veneer for cores.

In the case of plywood, between 1 and 2 inches in thickness, such as desk writing beds and flush doors, face veneers should be 1/16 to 1/20 inch, and crossings should be from 1/12 to 1/16 inch in thickness. Cores for both are usually made of narrow short strips, often offal from other woodworking operations. Except for larger sized and thicker layers, the principles of construction are the same.

## Veneer Core Plywood (5-Ply)

The suggestions concerning faces, backs and crossings apply as well to this class, usually called "panels," as to the lumber core plywood described in the foregoing.

A veneer core, however, even if made of prime basswood or poplar, is more likely to curl or warp than is a lumber core, and is not as certain to remain flat in service. The reason is not far to seek. Rotary cut veneer always tries to assume its original curve as before it was peeled from the log. Veneer cores, rather loosely cut, however, make quite a satisfactory core for most purposes, provided they are smoothly cut, of even thickness and well jointed and taped. The more careful plywood makers run their veneer cores (except less than 1/8 inch thick) through a planer to secure more uniform thickness and thereby produce a better quality of finished plywood.

## Lumber and Veneer Core Plywood (3-Ply)

Cores, veneer or lumber, should be more carefully made for 3-ply than for 5-ply plywood, since imperfections are more likely to show under the faces, and since the cross-banding is not available as a cover to hide irregularities in the cores where 3-ply construction is used. It is equally true that faces should be thicker in 3-ply and for substantially the same reason. However, most 3-ply plywood is used for cheaper or less particular construction than is 5-ply. Therefore, unusual care need not be exercised either in the selection of the raw material or in the manufacture of the finished product.

The 5-ply construction is always to be preferred for quality, strength and appearance, but the extra labor and material make it more costly. Where figured veneer is required and a high degree of finish is desired, 5-ply should always be used.

There are many places, however, where 3-ply construction will answer all requirements as well as 5-ply, and the saving in cost is quite worth while.

## Plywood with Equal Thickness of Each Ply

This construction (usually in 3-ply) had a purely utilitarian origin, i.e., to use the best veneers for the faces, the next for the back, and the poorest for the core, thus working up the entire product of the log, and utilizing the otherwise unused offal that occurs in either construction.

Door panels of pine, fir, gum and oak, are customarily made of three thicknesses 1/7 inch thick, sanding down so as to fit into a 3/8 inch groove, or 1/9 inch thick to fit a 5/8 inch groove, depending on the size of panel.

The plywood packing case is another example of "equal-thickness ply" construction made of three thicknesses of 1/20 or 1/16 inch rotary cut veneer. After gluing and cutting these sheet shooks to size, they are stiffened by means of wooden strips nailed on all four edges as shown in Illustration 181.

Illustration 181. Showing the automatic nailing machine, attaching cleats to plywood packing shooks. The man on the left is inspecting and clinching nails that may have not been done properly on machine.

Courtesy, Atlas Plywood Corporation.

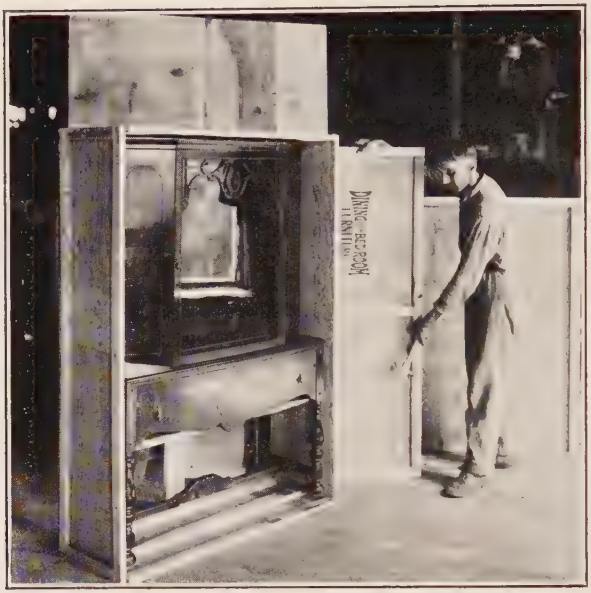

Illustration 182. Showing a china-closet, set in plywood packing case, ready to protect with excelsior pads, and nail up. Note that plywood cases with cleats require no additional bracing.

Courtesy, Atlas Plywood Corporation.

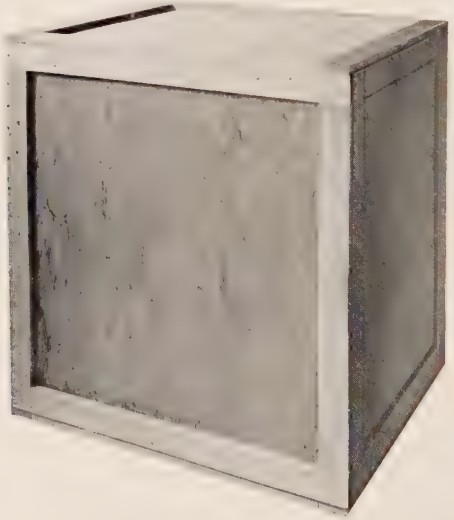

Illustration 183. Plywood packing case, nailed up and ready for shipment. Diagonal pressure on a plywood box (unbraced as shown) may be as great as 4,000 lbs. and cause deflection of less than 2 inches. Plywood boxes with 3 16 in. plywood (cleated) weigh only half that of boxes made of inch lumber.

Courtesy, Atlas Plywood Corporation.

These reinforced sheets are set up in a case as shown in Illustration 182, and when so set up may be used for a wide variety of merchandise packing.

The plywood shooks weigh less than half as much as lumber shooks, and are tougher and stronger in service. Illustration 183 shows a plywood packing case used to protect plywood furniture from injury during shipping.

Some stock panels are made in this way, but 1/4 inch stock panels are more often made with a 3/16 inch veneer core and 1/20 inch face and back.

This same style of equal thickness ply construction is used for player piano bellows stock, although the core wood often is of a different species and sometimes of a different thickness from face and back, thereby departing from the original utilitarian urge. In fact, this heavy veneer face and back, approximately equal each to core thickness, is sometimes called bellows construction.

This type of plywood is sometimes used in lieu of lumber core and crossings in making 5-ply tops. In other words, three plies of 1/4 inch veneer may be glued up as door panels described above. This is then sanded or planed to uniform thickness and smooth surface. On this, as a base, are glued the face and back veneers, resulting in a 13/16 inch top, all of veneer, without lumber. It is sometimes described as 5-ply with heavy crossings. The resulting plywood is not regarded as equal to that made from lumber centers, as it is more likely to warp, nor is it much less costly to make, as the gluing operation is divided and the parts are more awkward to handle.

## Flexible and Bent Plywood

Veneers do not bend easily against the grain, hence a flexible panel may be made with a very thin core of veneer, and thick faces of loose cut veneer. (See Illustration 180.) The old-fashioned sleigh was made using this class of plywood.

The flexibility of such plywood is surprising, but it is only suitable for painted work, and cannot be used with high grade face veneers.

Bent plywood carries this flexible plywood idea one stage further. The reverse curve opera seat should be bent rigid, not flexible, hence if a face and back of thin veneer are glued on to the above 3-ply flexible panel, it will result in a rigid bent 5-ply panel. It is, of course, made in one gluing operation and in nested cauls or dies, as previously described.

This rigid bent plywood can also be made in 3-ply, using a thin face and back, and a thick, loosely cut core, bending the core with the grain. This is cheaper and not equal to the 5-ply seat.

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Many other variations and combinations can be made in plywood construction, with more plies, or even number of plies, or angling and radial grain arrangements, each having its particular use and reason.

However, the great bulk of the plywood made falls within the four classes outlined.

# CHAPTER XXX

## TESTING METHODS

Up to the early days of the Great War, veneer and plywood products had received little technical or scientific attention. They were regarded as commercial developments, and the makers of plywood had neither time nor money to devote to research and testing. The possibility of using plywood in the manufacture of airplanes, fusilages and wing beam covers and for many purposes where heavy silk and other fabrics were previously used, put the whole subject in an entirely different light, and Government departments were immediately put to work on the subject. Starting with the proven fact that laminated wood or plywood may be stronger than steel, weight for weight, of what practical use could this be in winning the war? The Forest Products Laboratory at Madison, Wisconsin, under the joint auspices of the United States Department of Agriculture and the University of Wisconsin, had a nucleus of a research organization, and the problem was turned over to them.

Considerable literature was developed, but the results are too new, the scope of the investigations too limited and our perspective is too short to do justice to the subject. Much of the work and most of the results are too technical for a popular volume of this character. Some of the methods and results may be suggestive, and are briefly mentioned here.

### Testing Veneer

The testing of veneer was chiefly as a component part of plywood, to determine what any single ply might do under var-

ious conditions. A table of weights of veneer was determined, but it was found that different trees of a single species yielded veneer of varying weights—heart wood was heavier than sap, highland and lowland growths had different textures, and so on.

This table (in Report No. 84) should be used as approximate weights per square foot of oven dry veneer. Utilizing the glue weight given, it is possible to compute the weight of plywood, and reduce the same to pounds per square foot. The table is developed for the purpose of computing the approximate tensile strength of plywood per square inch and to determine the thickness required in basswood or ash to be equivalent to yellow birch.

## Testing Plywood

In addition to the tables on veneer tests just described, another table is given, showing the strength of the various species of wood when made into 3-ply.

Both of these series of tests, however, relate to the development of ultimate strength in plywood, and apply to airplane design, rather than to other industries where abundant strength can be obtained by sufficient size and weight. These tests are quite fully described in Report No. 84, (1920) of the National Advisory Committee for Aeronautics, under the heading, "Data on the Design of Plywood for Aircraft."

## Testing Glues

Tests of commercial glues have a much wider application than the veneer and plywood tests outlined above. The glue tests fall into two general forms, one for the constituents and qualities of the glue in powder and fluid form, and the other for the strength of joints made in various ways with different glues.

## Test on Animal Glue Mixtures

*Viscosity*[1] is determined by allowing a specified amount of glue at a definite temperature (usually 140° F.) to flow through a standard orifice. The time required is a measure of the viscosity. In general, high viscosity glues are stronger than low viscosity glues, but there are exceptions to this rule. There are a number of viscosimeters on the market for these tests.

*Jelly strength*[1] is a term referring to the firmness or elasticity of the jelly formed by cooling a glue solution of specified strength. Strong animal glues usually have high jelly strength. Most jelly tests are, therefore, comparative, to determine quality with a known sample.

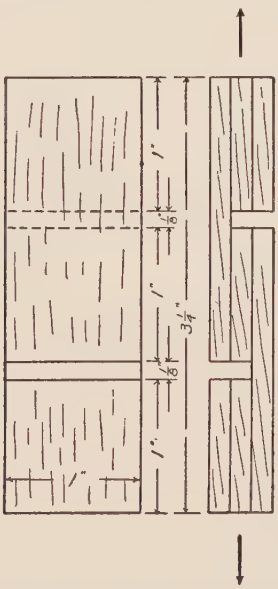


Illustration 184. Glue test specimen as made for the manufacture of plywood, adopted by the American and British governments during the World War.

Courtesy, Forest Products Laboratory.

[1] A bulletin describing "Standard Methods for Determining Viscosity and Jelly Strength," adopted by the National Association of Glue Manufacturers at Atlantic City, October 10, 1923, may be obtained from the National Association of Glue Manufacturers, 1355 West 31st Street, Chicago, Illinois.

Other tests are made of *odor, keeping quality, grease, foam* and reaction to *litmus.*

## Tests of Plywood Glue Joints

The British and the United States Governments have adopted similar methods for testing the strength of a plywood

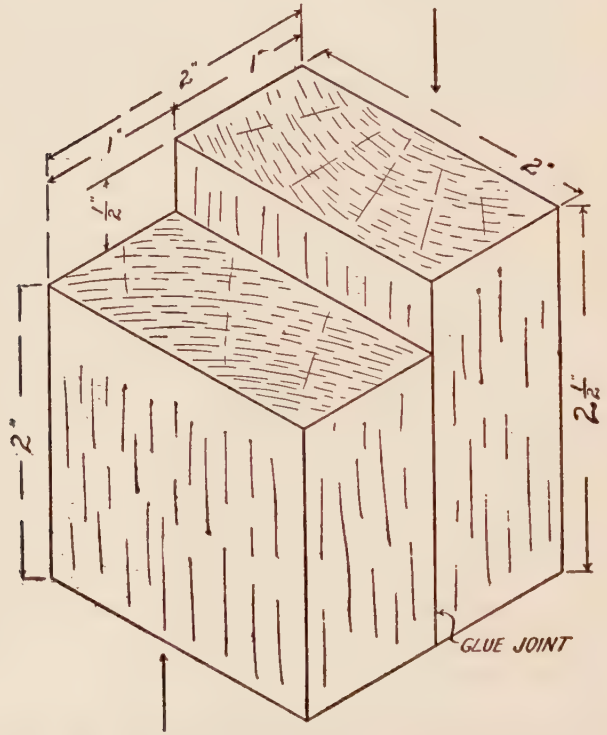


Illustration 185. Block shear test to indicate comparative glue strength. Blocks usually made of hard maple.

Courtesy, Forest Products Laboratory.

glue joint. Pieces of veneer are glued up into plywood, of the size and arrangement shown in Illustration 184. The arrangements of transverse grooves is such that when the sam-

ples are pulled apart in a testing machine, the separation must come on either one, or both, of the glue lines, or in the short center piece of veneer core.

The difficulty with this test is the lack of uniformity in mixing and applying glues to different woods under varying pressures. There are too many variable elements to isolate clearly the one of glue joint strength. This method, however, gives satisfactory comparative tests, where an unknown glue is tested under similar condition with one whose qualities are known to be satisfactory.

Another similar shear test, but under compression rather than tension, is shown in Illustration 185, usually made by gluing blocks of hard maple together and pushing rather than pulling them apart.

It must be admitted that the future holds a better glue testing method than has as yet been adapted to practical use.

# CHAPTER XXXI

## VENEER AND PLYWOOD EXHIBITIONS

It is more than probable that the lack of interest and information regarding the adaptation of veneer and plywood is largely because their utilization has never been emphasized nor promoted in any definite form. The average state fair is in the transition stage between the old-fashioned gathering, with races, gambling attractions and side shows, and the modern idea of an educational center where information and progressive methods are explained and demonstrated. The industrial exhibit, as well as the local and state demonstration of available raw materials and trade opportunities, is emerging as a distinct educational and trade promotional activity; in fact, it is a new and effective point of contact between the manufacturer and the consumer.

It is true that much plywood, in the form of furniture and pianos, has been exhibited at the annual and semi-annual market seasons of these two nation-wide industries, but the popular sentiment—due to lack of knowledge and information—against anything veneered, has in the past influenced the furniture manufacturer to place a minimum emphasis on the use of veneer and its combinations, and even occasionally to condone the lapse from truth, of the salesman who allows a customer to assume that he is buying "solid" construction when the construction is really plywood. This situation, however, is rapidly improving and the retail furniture organizations are co-operating with the furniture manufacturers in holding courses of instruction for salesmen; usually in connection with market exhibitions, in order to improve the abundant demonstration of actual construction. Such training and experience

Illustration 186. Showing exhibition booths at Milwaukee in 1924, at the Wisconsin Products Exhibition. Special emphasis was placed on veneers cut and plywood made within the state.

Courtesy, Wisconsin Veneer & Plywood Association.

Illustration 187. Showing exhibition booths at Milwaukee in 1925, at the Wisconsin Products Exhibition. Special emphasis was placed on veneers cut and plywood made within the state.

Courtesy, Wisconsin Veneer & Plywood Association.

Illustration 188 Exhibit of veneer and plywood at Detroit, in 1924.

Illustration 189—Showing exhibit at Buffalo by American Walnut Manufacturers' Association

will rapidly improve the methods and intelligence of selling well-made goods, and will acquaint the customer, as well as the general public, with the fact that the proper use of veneers and of plywood, actually improves the quality, makes for durability, and in almost all instances, increases the beauty and widens the opportunity for the more economical use of the choice figured woods.

The exhibition of veneers and plywood, for its own sake, has been well started by the Wisconsin Veneer and Plywood Association, which association has made two demonstrations at the Wisconsin Products Exhibition, besides co-operating with a similar exhibition in Detroit. Illustrations 186 to 188 show the booths used for the exhibit of veneers and plywoods. The opportunity, however, is much larger than is portrayed by these pictures.

Wood exhibits by the American Walnut Manufacturers' Association have included a number of figured walnut panels, as shown in Illustration 189.

When the intelligent use of veneers and of plywood is better understood and appreciated, largely through the instrumentality of such exhibits, the public at large will develop a real desire for the best made plywood and plywood-built furniture products.

# CHAPTER XXXII

## UTILIZATION OF PLYWOOD

Modern plywood is used in almost every walk of life, and to undertake to enumerate the wide range of its successful utilization would be a difficult, if not an impossible, task. Many of these uses have been explained or suggested as the steps of this story of plywood have been described.

Plywood construction increases the ultimate strength of wood, until it is stronger than steel on a weight basis. It exhibits the beauty of wood grain and figure until it rivals, if not surpasses, the skill of the artist. It also multiplies manyfold the benefits and enjoyment of this strength and beauty by supporting thin sheets of beautiful veneer on a durable foundation.

Furniture makers have used plywood from time immemorial, since the memory of man runneth not to the contrary, first with the idea of adornment and later because of lightness, grace and capacity to curve and bend. The chests and furniture pieces recently discovered in the tomb of "King Tut," the Bureau du Roi, Marie Antoinette's dressing table, Napoleon's campaign desk and chair, Dean Swift's secretary, the desk on which was written the Declaration of Independence, the table on which Betsy Ross designed and made our country's first flag, and many other equally famous pieces would have been impossible without the knowledge and without the practice of the art of veneering.

Plywood is used in furniture for tops and panels and leaves, ends, case backs, drawer fronts, dust and drawer bottoms, mirror backs, bed ends, foot and head panels, in fact for almost everything in cabinet and furniture making except legs, rungs,

rockers, frames and other obviously solid parts, and even these are sometimes adorned with veneer overlays and inlays.

Pianos would be strangely different and unrecognizable without their beautiful upright cases, curved falls, bent grand piano rims, laminated pin plank, and plywood bellows all built on the plywood principle.

Phonograph and radio cabinets, without grills, horns, panels, figured veneer doors and moulded tops and domes, would be clumsy and bulky. Our homes and offices would lose much of their dignity, without panelling in doors and wainscoting, without the artistic wall panelling and counters, without the handsome oak, walnut and mahogany writing desks and the convenient sectional bookcases made of plywood. The manufacturers of fibre board have made large panels for interior ceiling and wall panelling, but their appearance with or without paint, as compared with plywood panels of matched figure and uniform color is flat and characterless. Our kitchen cabinets, and toilet facilities, our nurseries and sewing rooms would be awkwardly equipped if it were not for the lithesomeness and grace of plywood products.

What of the packing cases and fruit packages, without the plywood shook? What of the orange, berry and melon cases? What of the baskets and boxes of many shapes and sizes, if there were no veneer? Is it not a fact that without veneer, from which to construct, these homely and useful containers, modern shipping would find its facilities sadly crippled?

Traveling with our personal belongings in heavy, solid, wooden chests would overcrowd the baggage cars and Pullman aisles. Plywood trunks and traveling cases are lighter and stronger than those made from any other material.

The auditorium, church, school, library, theatre and moving picture house would be equipped ponderously, uncomfortably and immovably without plywood in curved opera seating, the folding-chair in single and multiple units, the recitation settee, and the many forms and styles of school desks and seatings.

Our steel passenger, sleeping and dining cars are perhaps safer and more sanitary, but withal less beautiful and far less comfortable than when made with plywood interiors. A steel car is hot in summer and cold in winter, and always lacks the resilience of wood and wood parts.

The new transportation uses of plywood are many and obvious. The bodies of interurban buses, traveling our highways everywhere, are largely made of plywood, thus affording both maximum strength and durability. The airplane designers recognize the advantages of plywood strength and use it freely in the construction of our man-made birds of the air.

Plywood has only recently begun to be appreciated. Little is known of its ultimate possibilities. The making of plywood is at present a most modest business both in the number of men and in the amount of capital engaged in it, but the future opportunities are alluring and attractive.

What modern industry has in its origin—in its background, as it were—such romance, such an absorbing interest of antiquity? In fact, what other industry of today can trace its art and its history beginning almost with the dawn of creation on down through the ages to the present time?

What opportunity is greater than an artisanship and a craftsmanship that meets the exacting world demands of ultimate strength, in combination with maximum development of beauty and design, each on a sound basis of economy, utility and almost limitless durability?

# CHAPTER XXXIII

## SPECIFICATIONS, STATISTICS AND TABLES

### Standard Grade Rules for Veneer

Many groups of veneer manufacturers have developed private or local grade specifications for special species or requirements, which were eventually combined in the rules of the National Veneer & Panel Association. In 1922 this association became affiliated with the National Hardwood Lumber Association, and the rules were incorporated with the lumber grading rules of the latter association. The 1925 edition of these rules is as follows:

#### Veneer and Thin Lumber

#### Rotary Cut Cottonwood, Cypress, Gum, Poplar, Sycamore, Tupelo and Yellow Pine

Stock shall be of uniform and standard machine gauge thickness. Stock of all grades and kinds must be cut solid and dried so that it will not mold or damage in transit, and be sufficiently flat to straighten under the press without splitting.

Surface dimensions shall always be given: First, the thickness; second, the width across the grain, and, third, the length with the grain.

All specifications for special stock, not covered by these Rules, shall be a matter of special contract between the buyer and the seller.

Measurement. All log run and sheet stock of random widths shall be measured by taping and all dimension stock, in all grades, shall be computed on the basis of the sizes given and without allowance for trimming.

The standard grades of Commercial Rotary Cut Veneer shall be as follows:

Faces.
Sound Backs.
Reject Backs.
Drawer Bottoms.
Crossbanding.
Core, or center stock.
Selected, or unselected log run.
Selected, or unselected sheet stock.

CUTTING. The word "Cutting" as used in these rules means a portion of a sheet of veneer obtained by cross-cutting or ripping, or both. The term "clear face cutting" as used in these rules means a portion of the sheet of the veneer to be face grade and to be obtained by cross-cutting or ripping, or both.

DIMENSION STOCK. All dimension stock, in any thickness, in any kind of wood, shall be machine cut to the length specified, and if allowance is desired for trimming, buyer's specifications should be for length required, including trimming, and stock is to be billed and measured at actual length cut and all dimension sizes may be a trifle full as to width. Unless otherwise specifically stated, all stock for dimension sizes is to be cut to the sizes specified in one piece stock and in addition to include what part pieces the logs produce. Part pieces are to be of sufficient width to make allowance for jointing and part pieces are to be as wide as possible.

All dimension stock must be cut so that it will square to the dimension specified.

STANDARD GRADES: FACES. Stock of any thickness, in any kind of wood, unselected for color and shall be free from all defects except slight splits that will close in laying. Selected or figured face stock of any thickness to be the same grade as face stock except that it shall be selected as to color or figure.

SOUND BACKS. Stock of any thickness, in any kind of wood, unselected for color, and shall admit sound knots, firm doze, splits that will close in laying, pinworm holes, and discolorations. Stock to be smoothly cut.

REJECT BACKS. Stock of any thickness, in any kind of wood, unselected for color, and shall admit knots, worm holes, discolorations, grub or knot holes not over 1 inch in diameter, rough or loose cutting, open splits or checks not to exceed ½ inch in width and 25% of the length of the piece.

DRAWER BOTTOMS. Stock of any thickness, in any kind of wood, to be unselected for color. To be free from splits but may permit

small tight knots, sap stains and slight discolorations; otherwise to be face grade.

Crossbanding. Stock of 1/16 inch or less in thickness, in any kind of wood, to be unselected for color, free from open defects, but shall admit pinworm holes, sound discolorations and splits that will close in laying (splits to be not more than 15% of the length of the piece); no less than 60% of each size shall be free from knots and splits.

Unless otherwise specified fractional pieces may be included not to exceed 30% in each size specified (on fractional pieces, at least ½ inch must be allowed on each fractional piece for jointing).

Core, or Center Stock. Stock of 1/15 inch or thicker, in any kind of wood, to be unselected for color, to be free from open defects, but shall admit pinworm holes, sound discoloration, splits that will close in laying and other sound defects (splits to be no more than 15% of the length of the piece).

Unless otherwise specified, fractional pieces may be included not to exceed 30% in each size specified (on fractional pieces at least ½ inch must be allowed on each fractional piece for jointing).

Log Run. Log Run stock must grade no less than 30% clear face cuttings the full length or full width of the sheet, and no less than 50% cutting in core stock grade the full length or full width of the sheet, no cutting to be considered that is less than 6 inches in width.

In all thicknesses up to and including 1/15 inch, the stock shall be 6 inches and up wide, not less than 50% 18 inches and up wide; to be 48 inches and up long and at least 50% 60 inches and longer.

In thickness of 1/12 inch and thicker, the stock shall be 6 inches and up wide, not less than 50% 16 inches and up wide; to be 36 inches and up long and at least 50% 60 inches and longer.

Selected Log Run shall be of the same specifications except that it shall be selected for color.

Sheet Stock. Stock of any thickness must grade at least 50% clear face cutting, with not over 50% core stock cutting, all cuttings to be full length or full width of the sheet, no cutting to be considered that is less than 6 inches wide.

In all thicknesses up to and including 1/15 inch the stock shall be 9 inches and up wide, to be 48 inches and up long, with at least 75% 74 inches and longer.

In all thicknesses of 1/12 inch to ⅛ inch, inclusive, stock shall be 6 inches and up wide, at least 85% 11 inches and wider; to be 48 inches and up long, at least 90% 60 inches and longer, and must have at least 75% of the total 86 inches and longer.

In all stock thicker than ⅛ inch, the stock shall be 6 inches and up wide, at least 85% 11 inches and wider; to be 36 inches and up long, at least 90% 60 inches and longer, and must have not less than 75% of the total 74 inches and longer.

Selected sheet stock shall be of the same specifications, except that it shall be selected for color or figure.

When crating is specified on sheet stock grade, the veneer shall be crated one length to the crate and random widths.

### Rotary Cut Red Oak, White Oak and Chestnut

Faces. Stock of any thickness shall be free from all defects except slight splits that will close in laying, but shall admit bright sap showing character or grain figure.

Sound Backs. Stock of any thickness, unselected for color, and shall admit sound knots, firm doze, splits that will close in laying, pinworm holes and discolorations. Stock to be smoothly cut.

Reject Backs. Stock of any thickness, unselected for color, and shall admit knots, worm holes, discolorations, grub or knot holes not over 1 inch in diameter, rough or loose cutting, open splits or checks not to exceed ½ inch in width and 25% of the length of the piece.

Sheet Stock. Stock of any thickness, must grade at least 50% clear face cuttings the full length of the sheet, except in stock 1/12 inch and thicker under 82 inches long, which must grade at least 50% clear face cuttings either the full length or full width of the piece.

In all thicknesses up to and including 1/15 inch the stock shall be 6 inches and up wide, at least 90% 8 inches and up wide, and at least 75% 11 inches and up wide; to be 48 inches and up long, with at least 75% 74 inches and longer.

In all thicknesses of 1/12 inch and thicker the stock shall be 6 inches and up wide in all lengths 82 inches and longer; stock under 82 inches long to be 9 inches and up wide, the entire shipment to be at least 65% 11 inches and wider; to be 36 inches and up long, at least 75% 86 inches and up long.

In all thicknesses no cutting is to be considered that is less than 6 inches wide.

Where crating is specified on sheet stock grade, the veneer shall be crated one length to the crate and in random widths.

## Rotary Cut Ash, Basswood, Beech, Birch, Elm and Maple

No. 1 Grade (Faces). Stock of any thickness, free from knots, shall admit sap, splits that close, and slight discolorations.

Select No. 1. Stock of any thickness of the No. 1 grade except that it shall be selected as to color.

No. 2 Grade (Sound Backs, Cross-Banding Center Stock and Drawer Bottoms). Stock of any thickness shall admit sound knots, firm doze, splits that close, pinworm holes, discolorations, smoothly cut.

No. 3 Grade (Reject Backs and Box Stock). Stock of any thickness shall admit knots, worm holes, discoloration, grub or knot holes, not over 1 inch in diameter, rough or loose cutting, open splits and checks, not to exceed ½ inch in width and 25% of length of piece.

Selected Sheet Stock. All stock clear face, unselected for color, random widths, 5¼ inches to 38 inches wide; 42 inches long and longer. In all thicknesses up to and including 1/15 inch the stock shall be 9 inches to 38 inches wide; to be 42 inches and longer with 75% 62 inches and longer. In all thicknesses of 1/12 inch to ⅛ inch inclusive, the stock shall be 5¼ inches to 38 inches wide, 50% 11 inches and wider; to be 42 inches and up long, 75% to be 82 inches and longer.

Standard Sheet Stock. Unselected for color and random widths, 5¼ inches to 38 inches wide; 42 inches long and longer. In all thicknesses up to and including 1/15 inch, the stock shall be 9 inches to 38 inches wide; to be 42 inches long and longer, with 75% 62 inches and longer. Stock to grade 75% clear face cutting and all cutting to be full length or full width of the sheet. No cutting to be considered less than 9 inches wide. In all thicknesses of 1/12 inch to ⅛ inch inclusive, the stock shall be 5¼ inches to 38 inches wide, 50% 11 inches and wider; to be 42 inches and up long, 75% to be 82 inches and longer. Stock must grade 75% clear face cutting. All cutting to be full length or full width of the sheet. No cutting considered less than 5¼ inches wide.

Log Run. Log Run shall consist of stock of any thickness unselected for color and random widths and lengths 6 inches to 38 inches wide, 42 inches and up long, 75% to be 12 inches and up wide, 50% to be 82 inches and up long. To contain at least 50% of No. 1 face cuttings, no cutting to be figured less than 6 inches wide or under 42 inches long. Balance of the stock shall be suitable for No. 2 and No. 3 grades.

### Quartered Oak Veneer

MEASUREMENT. Tape measure shall be the standard measurement in all thicknesses, and the width shall be taped midway of the flitch.

In computing the feet in a flitch the actual length of the flitch shall be used. Multiply the width in feet and inches as shown by the tape by the length of the flitch to obtain the number of square feet the flitch contains.

In determining the width of a bevel flitch, the average width of the sheets shall be the width of the flitch.

In computing defects, the flitch shall be taken as a unit. The percentage of defects, allowed in each grade as herein stated is figured on the total square feet contained in a flitch.

CUTTING. The term "cutting," as used in these rules, means a "piece of veneer" free from defects.

FIGURE. All flitches must show 90% of figure in the aggregate.

GRADES. There shall be two grades of veneer, standard and common.

STANDARD GRADE. All flitches in which the defects do not exceed 10 per cent of the total feet in the flitch shall be measured full.

Flitches containing defects not to exceed 20 per cent of the total feet in the flitch may be cut in measurement 10 per cent of the total feet in the flitch to raise the veneer to this grade.

In estimating defects no cutting to be considered less than 6 inches wide by 24 inches long.

Bright sap shall not be considered a defect. Widths shall be 6 inches and up with widths specified.

Lengths shall be 4 feet and over, not over 5 per cent to be under 7 feet.

COMMON GRADE. Flitches shall be cut two-thirds clear, no cutting to be less than 5 inches wide by 18 inches long.

Bright sap shall not be considered a defect.

Widths shall be 5 inches and not over 10 inches.

Lengths shall be 4 feet and over, not over 5 per cent to be under 7 feet.

NOTE. Any other specification for veneer, other than these rules, shall be a matter of special contract between buyer and seller.

## Standard Grade Rules for Plywood

Various systems of grade rules have been devised for the manufacturing and selling of plywood, but none have treated

the subject comprehensively. The present basis, adopted by the National Hardwood Lumber Association, is a revision of the tabular form originally developed by the Plywood Manufacturers' Association. Both of these systems are in skeleton form, and do not differentiate between the various species of woods, the thicknesses of the faces and crossings, the methods of banding or railing cores, the kinds of glue used, and various other important details that must eventually take their proper place in a comprehensive system of classifying such a diversified product as plywood.

The 1925 edition of the National Hardwood Lumber Association rules are as follows:

## Plywood

### Specifications for Faces of Panels and Tops

Grade A. Figured and plain woods, matched for uniform figure and color. Excessive discoloration, face depressions, sap, knots and worm holes eliminated. Smooth finished. (See Notes Nos. 2 and 3.)

Grade 1. Random figure or grain, matched for color only. Tight joints. Sap, slight discoloration and sound pin knots not considered defects. Patches properly made permissible. Sanded or scraped. (See Notes Nos. 2 and 3.)

Grade 2. Not matched for color or grain. Slightly open joints, sap with discolorations, burls, sound knots and patches permissible. Sanded or scraped.

Grade 3. Any kind or kinds of wood. Doze, stain, pithy knots, discolorations, burls, loose cutting and open joints permissible. Not sanded. Tape not removed.

Specifications for Backs of Panels and Tops Good Backs. Specifications same as for Grade 1 Faces.

Sound Backs. Specifications same as for Grade 2 Faces.

Reject Backs. Any kind or kinds of wood. Supplied on panels with one good face unless another grade is specified. May contain doze, stain, unsound knots, worm holes, checks, loose or rough cutting, splits and open joints. Not sanded. Tape not removed.

NOTES.

*Note No.* 1. Any specifications for Face and Back Veneer other than these rules shall be a matter of special contract between buyer and seller.

*Note No.* 2. In some instances it is desirable to include sap to produce best effect in matching in Walnut, Figured Gum and other woods on the Faces; therefore, the matter of eliminating sap is considered optional.

*Note No.* 3. Slight mineral streaks are not considered a defect in Plain and Quartered Oak.

### Specifications for Lumber Cores

GRADE A. Made from any suitable core wood. Mixed woods in the same core not permitted. Sound knots, patching and minor defects permissible. All joints machined and tightly glued. All exposed edges must be sound.

GRADE 1. Any suitable wood. Mixed wood not permitted in the same core. Slightly open joints permitted.

GRADE 2. Any kind or kinds of wood permitted, and may be mixed in the same core. Must be reasonably sound, but doze, stain, small open knots or pin worm holes and checks are permitted.

NOTE. Any specifications for Lumber Cores other than these rules shall be a matter of special contract between buyer and seller.

## Chart of Grade Rules for Plywood

The original tabular form, adopted by the Plywood Manufacturers' Association in 1921, and which is still used by many plywood manufacturers, because of its arrangement and classification, is shown in Figure 190.

## Log Measure

There are a large number of rules in the country today, purporting to give the contents of logs of given dimensions in feet, board measure. Among these rules there is wide variation in the value given to logs of the same dimensions. In the manner of their use, too, there is a good deal of divergence, resulting sometimes in dispute and loss.

| CONSTRUCTION | | FIGURED WOODS | | PLAIN WOODS | | |
|---|---|---|---|---|---|---|
| | | **A A** Extra Grade | **A** Standard Top Grade | **B** Standard Grade | **C** Exposed Work where Matching for Color Unnecessary | **D** Semi-exposed Work |
| FACES | | Carefully matched for figure and color.<br>All joints glued.<br>Veneers clear and free from all defects such as sap, stains, worm holes, sound knots, etc.<br>Machine sanded, belt finished. | Random figure, average matched for color.<br>Streaks, small stains and sound pin knots allowed.<br>Scraped or sanded | Clear veneers, selected and matched for color.<br>Properly jointed and taped.<br>Properly made patches permitted.<br>Scraped or sanded. | May contain tight jointed veneers, not matched for color or grain; burls, pin knots, patches properly made; mineral stains or natural discolorations in live timber not a defect.<br>Scraped or sanded. | Veneers may have doze or stain; small knots with bark or pith in centers pin worm holes plugged; closed end checks; loose or rough cutting glued tight.<br>Slightly open joints permitted.<br>Scraped or sanded. |
| FACE CROSSINGS | | One piece, clear stock, tight cut. | Piecing permitted, when properly jointed and taped. | | Piecing permitted without jointing or taping. | Made only in 3-ply. |
| CORES | LUMBER | Mixed lumber core not permissible.<br>Knots and defects all cut out.<br>All joints machined and tightly glued. | Any suitable core wood.<br>Sound knots, patching and minor defects permissible.<br>Sawed joints allowed.<br>Slightly open joints permissible. | | | Not made with lumber cores. |
| | ROTARY | Stock, one piece (or glued joints), clear of defects, smooth and well cut. | Piecing permitted when properly jointed and taped. | | Piecing permitted, without jointing or taping. | |
| BACK CROSSINGS | | Same as face crossings, but more than one piece permitted when jointed and taped. | Same as face crossings | | | Made only in 3-ply |
| BACKS | REJECT | Not used in this grade unless requested. | Veneers may have doze, stain, small knots with bark or pith in centers; pin worm holes; end checks; loose or rough cutting. Open joints permitted. | | | |
| | SOUND | Jointed veneers with tight joints; veneers not matched for color or grain; burls, pin knots, patches properly made; mineral stains or natural discolorations in live timber not a defect. Scraped or sanded. For better than sound backs, use face grades. | | | | |

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**A A A**

Applies to figured face veneers, center, butt and pattern matched.

Otherwise like "AA."

ADOPTED AT CINCINNATI, FEB. 9, 1921 BY PLYWOOD MANUFACTURERS ASSOCIATION 1215 MONADNOCK BLDG. CHICAGO

**D D** Concealed Work

May be any kind of wood and may contain open joints or checks not over ½" wide, 12" long or half the length of the panels if under 24" long.

Pin worm holes, grub or knot holes not over 2" in diameter.

Rough or loose cutting, doze and stain.

Illustration 190. Plywood grade rule chart.

Several of the more common veneer log rules will be briefly outlined[1] and two, tabulated:

SCRIBNER. The figures of the original Scribner rule were obtained by drawing diagrams of the end sections of logs 12 to 48 inches in diameter and the boards which in the mill practice of the time could be sawed out of them. It is a very old rule and in wide use. As printed, extended down to 6 inches, it is the legal rule in the State of Minnesota.

DECIMAL. Omitting unit figures of the Scribner rule and taking the nearest tens has given the Decimal rule, so called, begun in Wisconsin and adopted by the United States Forest Service.

DOYLE. This rule was constructed by the following formula: Deduct 4 inches from the diameter of the log for slab, square ¼ of the remainder, and multiply by the length of the log in feet. This is a very illogical rule and gives results widely varying from saw product in logs of different sizes, though in a run of logs the results obtained may approximate a fair thing. Very small values are given to small logs, too small by far for normal logs economically manufactured, while beyond about 36 inches in diameter values are given that are above the product of the saw. It crosses the Scribner rule at 25 inches in diameter, the Maine rule at 34. . . .

The Doyle rule is in more general use than any other in the United States and Canada, and is the one printed in recent editions of Scribner's "Lumber and Log Book."

DOYLE-SCRIBNER. This rule has been combined with the Scribner into the Doyle-Scribner rule, the figures of the Doyle rule being taken for small logs where the Doyle figures are lower, and of the Scribner rule on the largest logs where these figures are less. This Doyle-Scribner rule has been used largely on hard woods.

[1] "Manual for Northern Woodsmen," by Austin Carey. Published by Harvard University Press, 1924.

TABLE I

DOYLE LOG RULE

In feet log measure

| Diameter in Inches | LENGTH OF LOG IN FEET | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 18 | 20 | 22 | 24 |
| 8 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 18 | 20 | 22 | 24 |
| 9 | 12 | 14 | 16 | 17 | 19 | 20 | 22 | 23 | 25 | 28 | 31 | 34 | 37 |
| 10 | 18 | 20 | 23 | 25 | 27 | 29 | 32 | 34 | 36 | 41 | 46 | 50 | 54 |
| 11 | 24 | 28 | 31 | 34 | 37 | 40 | 43 | 46 | 49 | 55 | 61 | 67 | 74 |
| 12 | 32 | 36 | 40 | 44 | 48 | 52 | 56 | 60 | 64 | 72 | 80 | 88 | 96 |
| 13 | 40 | 46 | 50 | 55 | 61 | 66 | 71 | 76 | 81 | 91 | 101 | 111 | 122 |
| 14 | 50 | 56 | 62 | 69 | 75 | 81 | 88 | 94 | 100 | 112 | 125 | 137 | 150 |
| 15 | 60 | 68 | 75 | 83 | 91 | 98 | 106 | 113 | 121 | 136 | 151 | 166 | 181 |
| 16 | 72 | 81 | 90 | 99 | 108 | 117 | 126 | 135 | 144 | 162 | 180 | 198 | 216 |
| 17 | 84 | 95 | 106 | 116 | 127 | 137 | 148 | 158 | 169 | 190 | 211 | 232 | 253 |
| 18 | 98 | 110 | 122 | 135 | 147 | 159 | 171 | 184 | 196 | 220 | 245 | 269 | 294 |
| 19 | 112 | 127 | 141 | 155 | 169 | 183 | 197 | 211 | 225 | 253 | 280 | 309 | 338 |
| 20 | 128 | 144 | 160 | 176 | 192 | 208 | 224 | 240 | 256 | 288 | 320 | 352 | 384 |
| 21 | 144 | 163 | 181 | 199 | 217 | 135 | 153 | 271 | 289 | 325 | 361 | 397 | 433 |
| 22 | 162 | 182 | 202 | 223 | 243 | 263 | 283 | 303 | 324 | 364 | 404 | 445 | 486 |
| 23 | 180 | 203 | 226 | 248 | 271 | 293 | 313 | 336 | 359 | 406 | 452 | 496 | 541 |
| 24 | 200 | 225 | 250 | 275 | 300 | 325 | 350 | 375 | 400 | 450 | 500 | 550 | 600 |
| 25 | 220 | 248 | 276 | 303 | 331 | 358 | 386 | 413 | 441 | 496 | 551 | 606 | 661 |
| 26 | 242 | 272 | 302 | 334 | 363 | 393 | 423 | 458 | 484 | 544 | 605 | 665 | 726 |
| 27 | 264 | 297 | 330 | 363 | 397 | 430 | 463 | 496 | 530 | 596 | 661 | 726 | 794 |
| 28 | 288 | 324 | 360 | 396 | 432 | 468 | 504 | 540 | 576 | 648 | 720 | 792 | 864 |
| 29 | 312 | 352 | 391 | 430 | 469 | 508 | 547 | 586 | 625 | 703 | 782 | 860 | 938 |
| 30 | 338 | 380 | 422 | 465 | 507 | 549 | 591 | 633 | 676 | 761 | 845 | 930 | 1014 |
| 31 | 364 | 410 | 456 | 502 | 547 | 592 | 638 | 683 | 729 | 820 | 912 | 1004 | 1094 |
| 32 | 392 | 441 | 490 | 539 | 588 | 637 | 686 | 735 | 784 | 882 | 980 | 1079 | 1176 |
| 33 | 420 | 473 | 526 | 578 | 631 | 683 | 736 | 789 | 841 | 946 | 1051 | 1156 | 1262 |
| 34 | 450 | 506 | 562 | 619 | 675 | 731 | 787 | 844 | 900 | 1012 | 1125 | 1237 | 1350 |
| 35 | 480 | 540 | 601 | 661 | 721 | 781 | 841 | 901 | 961 | 1081 | 1202 | 1322 | 1442 |
| 36 | 512 | 576 | 640 | 704 | 768 | 832 | 896 | 960 | 1024 | 1152 | 1280 | 1408 | 1536 |
| 37 | 544 | 613 | 681 | 749 | 817 | 884 | 953 | 1021 | 1089 | 1225 | 1361 | 1497 | 1634 |
| 38 | 578 | 650 | 723 | 795 | 867 | 939 | 1011 | 1083 | 1156 | 1300 | 1446 | 1590 | 1734 |
| 39 | 612 | 689 | 765 | 842 | 910 | 996 | 1070 | 1149 | 1225 | 1379 | 1530 | 1684 | 1838 |
| 40 | 648 | 729 | 810 | 891 | 972 | 1053 | 1134 | 1215 | 1296 | 1458 | 1620 | 1782 | 1944 |
| 41 | 684 | 770 | 856 | 941 | 1027 | 1112 | 1198 | 1284 | 1369 | 1540 | 1711 | 1882 | 2053 |
| 42 | 722 | 812 | 902 | 993 | 1083 | 1173 | 1264 | 1354 | 1444 | 1625 | 1805 | 1986 | 2166 |
| 43 | 761 | 856 | 951 | 1046 | 1141 | 1237 | 1331 | 1426 | 1521 | 1711 | 1902 | 2091 | 2282 |
| 44 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1400 | 1500 | 1600 | 1800 | 2000 | 2200 | 2400 |

Courtesy, Harvard University Press, publishers of "Manual for Northern Woodsmen," by Austin Carey, 1924.

## Table II

Scribner Log Rule—In feet log measure

| Diameter in Inches | Length of Log in Feet | | | | | | |
|---|---|---|---|---|---|---|---|
| | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 6 | 12 | 14 | 18 | 22 | 24 | 28 | |
| 7 | 18 | 24 | 28 | 32 | 34 | 38 | |
| 8 | 24 | 28 | 32 | 40 | 44 | 48 | |
| 9 | 30 | 35 | 40 | 45 | 50 | 55 | |
| 10 | 40 | 45 | 50 | 55 | 65 | 70 | |
| 11 | 50 | 55 | 65 | 70 | 80 | 90 | |
| 12 | 59 | 69 | 79 | 88 | 98 | 108 | 118 |
| 13 | 73 | 85 | 97 | 109 | 122 | 134 | 146 |
| 14 | 86 | 100 | 114 | 129 | 143 | 157 | 172 |
| 15 | 107 | 125 | 142 | 160 | 178 | 196 | 214 |
| 16 | 119 | 139 | 159 | 178 | 198 | 218 | 238 |
| 17 | 139 | 162 | 185 | 208 | 232 | 255 | 278 |
| 18 | 160 | 187 | 213 | 240 | 267 | 293 | 320 |
| 19 | 180 | 210 | 240 | 270 | 300 | 330 | 360 |
| 20 | 210 | 245 | 280 | 315 | 350 | 385 | 420 |
| 21 | 228 | 266 | 304 | 342 | 380 | 418 | 456 |
| 22 | 251 | 292 | 334 | 376 | 418 | 460 | 501 |
| 23 | 283 | 330 | 377 | 424 | 470 | 518 | 566 |
| 24 | 303 | 353 | 404 | 454 | 505 | 555 | 606 |
| 25 | 344 | 401 | 459 | 516 | 573 | 631 | 688 |
| 26 | 375 | 439 | 500 | 562 | 625 | 688 | 750 |
| 27 | 411 | 479 | 548 | 616 | 684 | 753 | 821 |
| 28 | 436 | 509 | 582 | 654 | 728 | 800 | 873 |
| 29 | 457 | 533 | 609 | 685 | 761 | 838 | 914 |
| 30 | 493 | 575 | 657 | 739 | 821 | 904 | 986 |
| 31 | 532 | 622 | 710 | 799 | 888 | 976 | 1065 |
| 32 | 552 | 644 | 736 | 828 | 920 | 1012 | 1104 |
| 33 | 588 | 686 | 784 | 882 | 980 | 1078 | 1176 |
| 34 | 600 | 700 | 800 | 900 | 1000 | 1100 | 1200 |
| 35 | 657 | 766 | 876 | 985 | 1095 | 1204 | 1314 |
| 36 | 692 | 807 | 923 | 1038 | 1152 | 1268 | 1380 |
| 37 | 772 | 901 | 1029 | 1158 | 1287 | 1416 | 1544 |
| 38 | 801 | 934 | 1068 | 1201 | 1335 | 1468 | 1602 |
| 39 | 840 | 980 | 1120 | 1260 | 1400 | 1540 | 1680 |
| 40 | 903 | 1053 | 1204 | 1354 | 1505 | 1656 | 1806 |
| 41 | 954 | 1113 | 1272 | 1431 | 1590 | 1748 | 1908 |
| 42 | 1007 | 1175 | 1343 | 1511 | 1679 | 1848 | 2014 |
| 43 | 1046 | 1222 | 1396 | 1571 | 1745 | 1918 | 1092 |
| 44 | 1110 | 1295 | 1480 | 1665 | 1850 | 2034 | 2220 |
| 45 | 1139 | 1329 | 1518 | 1707 | 1898 | 2088 | 2278 |
| 46 | 1190 | 1388 | 1587 | 1785 | 1983 | 2180 | 2380 |
| 47 | 1242 | 1449 | 1656 | 1862 | 2070 | 2276 | 2484 |
| 48 | 1296 | 1512 | 1728 | 1944 | 2160 | 2376 | 2592 |

Courtesy, Harvard University Press, publishers of "Manual for Northern Woodsmen," by Austin Carey, 1924.

## Statistics of Veneer Manufacture

Detailed tabulations of the various species of wood used in the manufacture of domestic veneers from native and imported timbers are given for the years 1911 to 1923 in the bulletin, published in 1925 by the Department of Commerce, "Census of Manufactures: 1923," entitled, "The Principal Lumber Industries," to which source the reader is referred.

The following charts were prepared showing relative consumption of veneers in the different woods and different localities, together with the proportion cut by different methods.

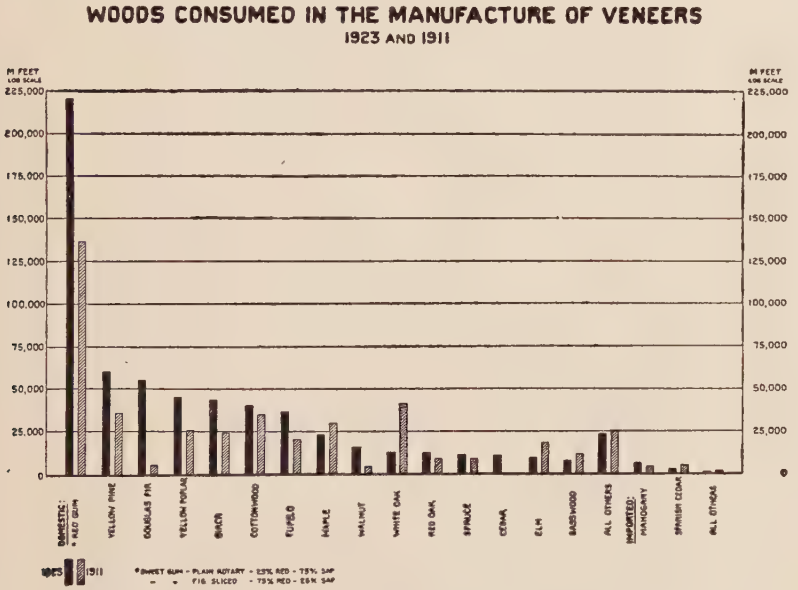


Illustration 191. U. S. Bureau of Census figures.
Courtesy, Commercial Research, Curtis Publishing Co.

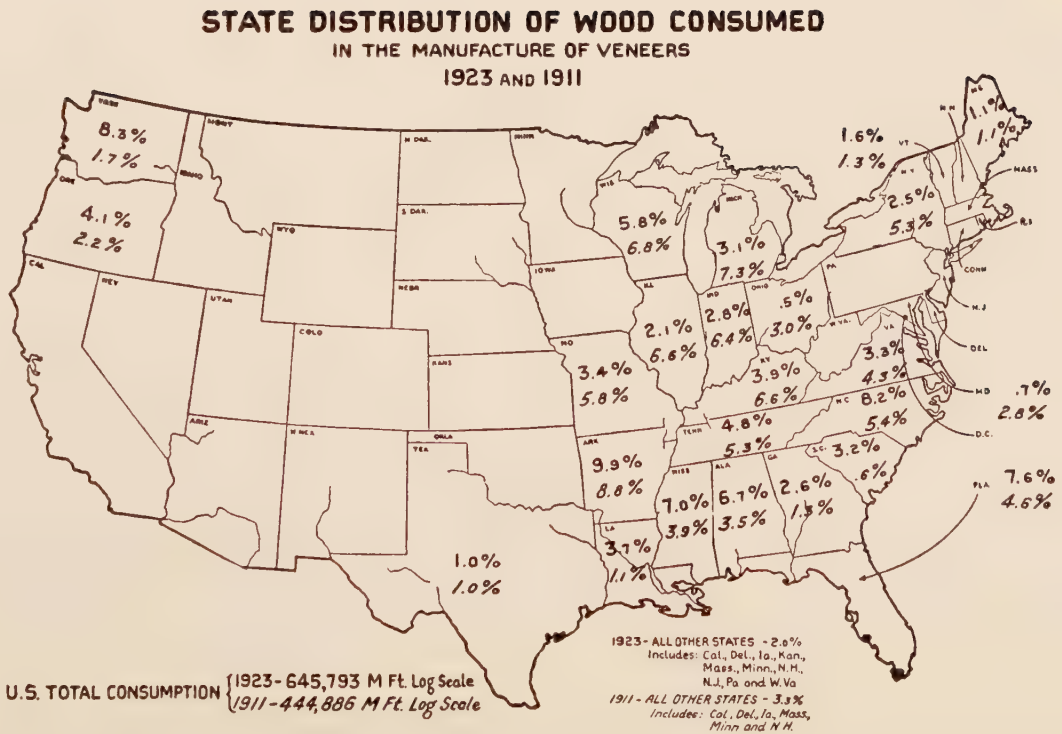


Illustration 192. U. S. Bureau of Census figures.
Courtesy, Commercial Research, Curtis Publishing Co.

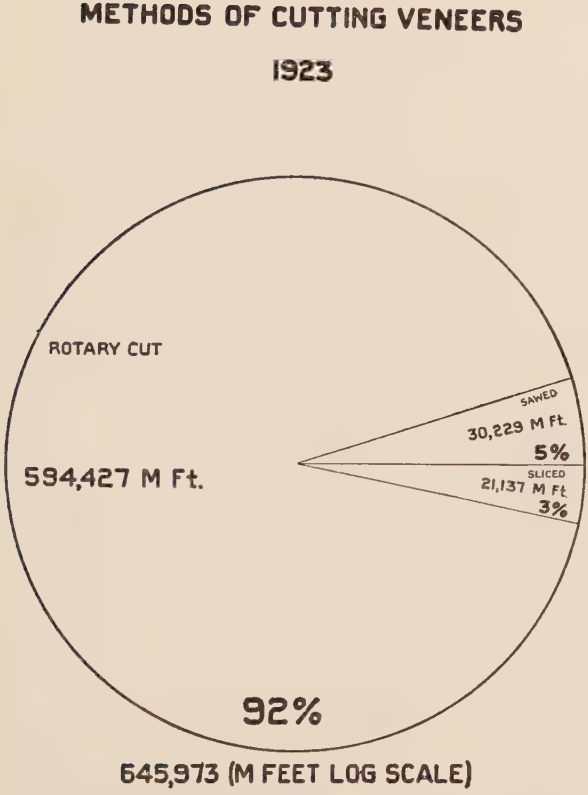


Illustration 193. U. S. Bureau of Census figures.
Courtesy, Commercial Research, Curtis Publishing Co.

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F–2 Strength of commercial liquid glues.

F–3 Aluminum leaf to moisture-proof wood.

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